



EXOTIC CAULERPA AT AOTEA GREAT BARRIER ISLAND

APRIL 2024

BARRY SCOTT



Exotic Caulerpa at Aotea/Great Barrier Island Barry Scott

Background

Exotic caulerpa was first detected in Okupe/Blind Bay on Aotea/Great Barrier Island in June 2021. A local botanist, Jack Warden was out fishing at the time and observed the presence of an unusual seaweed growing in the Bay so made a post on the citizen science website iNaturalist^{1,2}. Sergio Díaz-Martínez, a researcher from the National Autonomous University of Mexico who had previously worked at NIWA, spotted the entry and noted it appeared to be a *Caulerpa* species not present in New Zealand. He tagged a NIWA scientist who notified Biosecurity New Zealand on the 5th July 2021 and arranged for samples to be collected from Okupe³.

Figure 1: *Caulerpa brachypus* at Okupe (Barry Scott)



The Marine Invasive Taxonomic Service at NIWA identified the samples as *Caulerpa brachypus* (Harvey, 1860), a non-native marine macro-alga not previously detected in New Zealand⁴ (Figure 1). *C. brachypus* is a seaweed native to the Indo-Pacific region, which ranges from Africa to Australia, the Pacific Islands and Japan. It has blade-shaped fronds that are up to 10 cm long, arising from long runners known as stolons (Figure 2). There are nine native species of *Caulerpa* in New Zealand, with three occurring around Aotea: *C. articulata*, *C. flexilis* and *C.*

¹ iNaturalist link: <https://www.inaturalist.org/observations/84272350>

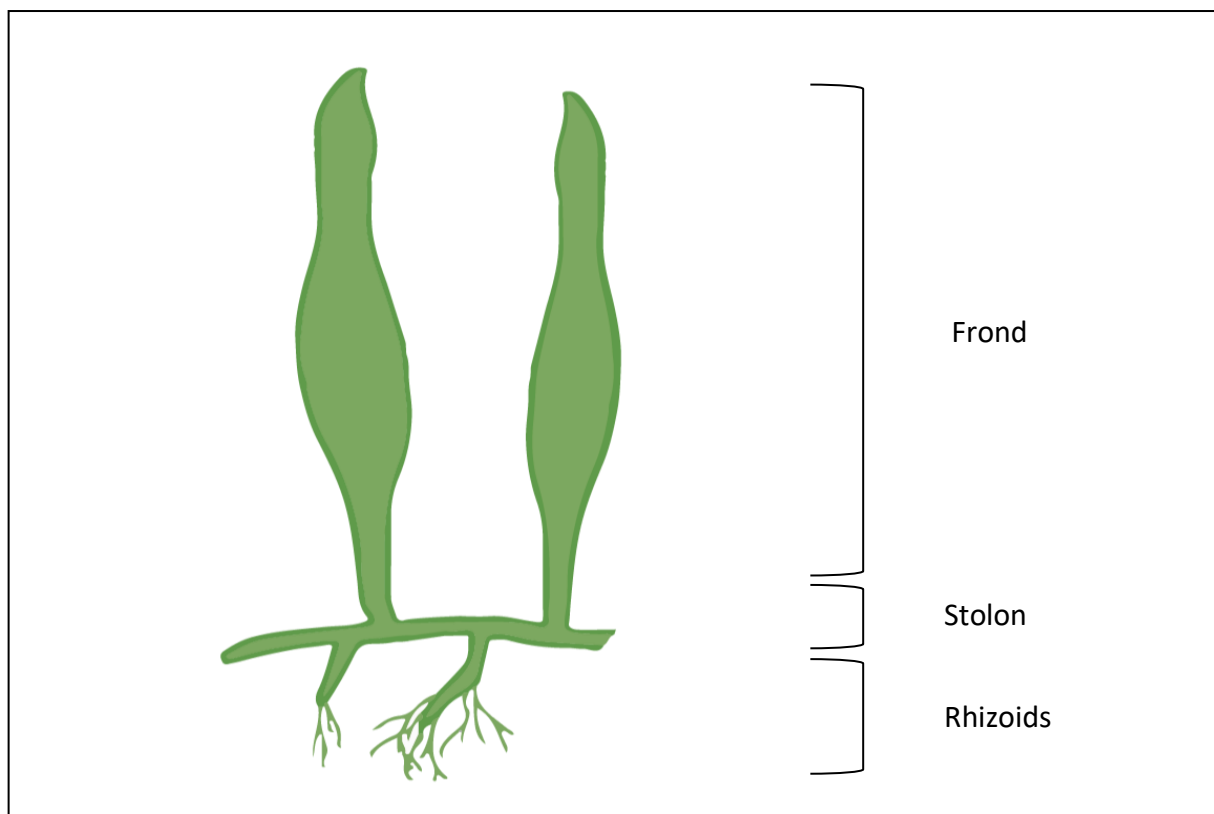
² Marine Pests post: <https://www.marinepests.nz/news/local-fisherman-first-to-detect-invasive-seaweed-at-aotea-great-barrier-island>

³ *Caulerpa brachypus*, a highly invasive non-native seaweed found in Aotea Great Barrier Island Harbours – by Barry Scott. Environmental News, Issue 45, Summer 2022. <https://www.gbiet.org/en45-caulerpa-brachypus-invasion>

⁴ Biosecurity Response Sheet: <https://www.mpi.govt.nz/dmsdocument/46393-Caulerpa-Great-Barrier-Island-2021-Biosecurity-Response-Fact-sheet>

*geminata*⁵, but their morphology is very different to *C. brachypus*⁶. A close relative, *C. taxifolia*, is listed as a Notifiable Organism under the Biosecurity Act. A cold-tolerant strain of this species was bred for use in the aquarium trade, but unfortunately was accidentally released from the Oceanographic Museum of Monaco in 1984, resulting in one of the largest and most devastating seaweed incursions in the Mediterranean. Incursions of *C. taxifolia* were later identified in New South Wales⁷ and in California⁸. The ability of *C. taxifolia* to produce the toxin, caulerpenyne, which inhibits the growth of many marine animals, led Alexandre Meinesz to coin the term *Killer Algae* to describe this species⁹.

Figure 2: Structure of *Caulerpa brachypus*



⁵ Wendy Nelson (2020). New Zealand Seaweeds. An illustrated guide. Te Papa Press. Pages 26-29.

⁶ Inglis G and Middleton I (2023). Caulerpa species and relevance to control methods. In 2023 Exotic Caulerpa suction dredge technical advisory group report. Biosecurity New Zealand Discussion Paper No:2023/03 prepared for Caulerpa Response by the Suction Dredge Technical Advisory Group. ISBN No: 978-1-991087-30-0 (online). 10 July 2023. <https://www.mpi.govt.nz/dmsdocument/58177-Exotic-Caulerpa-Suction-Dredge-Technical-Advisory-Group-Report>

⁷ Creese et al. (2004). Eradicating and preventing the spread of the invasive alga *Caulerpa taxifolia* in NSW NSW Fisheries Final Report Series No. 64. ISSN1440-3544.

⁸ Steering Committee of the Southern California Caulerpa Action Team. February 2005. Southern Californian *Caulerpa taxifolia* eradication program. *Caulerpa taxifolia* survey efficacy assessment at Agua Hedionda lagoon and Huntington Harbour.

⁹ Alexandre Meinesz (1999). *Killer Algae. The true tale of a biological invasion.* Translated by Daniel Simberloff. The University of Chicago Press.

Biosecurity New Zealand Response

Following the initial detection of *C. brachypus* in Okupe Bay, Biosecurity New Zealand set up a partnership with Aotea mana whenua, Aotea Great Barrier Local Board, Auckland Council and the Department of Conservation to respond to the incursion through a Mana – Enhancing Agreement. The response, which operated under a formal structure outlined under the Coordinated Incident Management System (or CIMS), set out “to understand the distribution of exotic caulerpa, contain the known sites of infestation, and work collaboratively on potential management and surveillance options.” This group became known as the Aotea Caulerpa Governance Group. In August 2021 Biosecurity New Zealand commissioned NIWA to carry out a dive survey of Okupe/Blind Bay (~88 ha) to determine the extent of the invasion. Video footage showed extensive spread of the exotic caulerpa across an estimated area of 44 ha of the bay¹⁰, much of it in large ‘meadows’. Further dives in Tryphena Harbour revealed pockets of *C. brachypus* in this harbour as well¹¹. Because this species had the potential to have serious impacts on native marine organisms and ecosystems, Biosecurity New Zealand placed a Controlled Area Notice (CAN) on Okupe/Blind Bay and Tryphena Harbour on 20th September 2021 to minimize its spread¹². Mana whenua supported this response with the placement of a rāhui over the same areas. To highlight the importance of the rāhui, three pou whenua were erected at Okupe Beach, Pa Point and Port Fitzroy¹³.

Further surveillance by NIWA in September 2021 showed that exotic caulerpa was also present in Whangaparapara Harbour, so the CAN controls and rāhui were extended to this bay as well on 16th October 2021¹⁴. The CAN and rāhui were in place until 30th June 2022 but then extended through till 30th November 2023.

The CAN made it illegal for boats to anchor in these three harbours although they were able to use fixed moorings. Vessels that were anchored in the three areas at the time had to get a permit from Biosecurity New Zealand to lift anchor and move. It also became illegal to take any marine life (e.g. fish, shellfish, crayfish, seaweed) from the three affected harbours. These strict rules were imposed because *C. brachypus* was known to spread easily by fragmentation, which would occur with activities such as dredging or anchoring. Full details of the CAN rules, maps of the controlled areas and what the public were required to do if they thought they detected *C. brachypus* were released on the MPI web site, which has been regularly updated (www.biosecurity.govt.nz/caulerpa).

¹⁰ Link to video footage of *Caulerpa brachypus* on seabed of Blind Bay: <https://www.facebook.com/watch/?v=1455558218133461>

¹¹ *Caulerpa brachypus* update: <https://www.mpi.govt.nz/biosecurity/major-pest-and-disease-threats/caulerpa-brachypus-a-non-native-seaweed>

¹² BNZ newsletter update to the community - Update 1, 1 October 2021. <https://www.mpi.govt.nz/biosecurity/exotic-pests-and-diseases-in-new-zealand/pests-and-diseases-under-response/exotic-caulerpa-seaweeds-caulerpa-brachypus-and-caulerpa-parvifolia-in-new-zealand/#science>

¹³ BNZ newsletter update to the community - Update 5, 20 December 2021.

<https://www.mpi.govt.nz/biosecurity/exotic-pests-and-diseases-in-new-zealand/pests-and-diseases-under-response/exotic-caulerpa-seaweeds-caulerpa-brachypus-and-caulerpa-parvifolia-in-new-zealand/#science>

¹⁴ BNZ newsletter update to the community - Update 2, 15 October 2021.

Two species

After the initial confirmation that the *Caulerpa* species found in Okupe/Blind Bay was *C. brachypus*, further molecular analysis in November 2021, using molecular phylogeny of DNA sequences from the chloroplast gene, *tufA*^{15,16} was carried out on caulerpa samples from Tryphena and Whangaparapara harbours. Surprisingly, two closely related species were found to be present in Tryphena: *C. brachypus* and *Caulerpa parvifolia*. But interestingly, just *C. parvifolia* was identified in Whangaparapara Harbour¹⁷. Although *C. parvifolia* has been reported to occur at many tropical and sub-tropical locations reliable molecular data are only available for a limited number of these locations. The Aotea samples clustered most closely with those from Lord Howe Island, Norfolk Island and Coffs Harbour. Both *Caulerpa* species are very similar in morphology and growth habit and can only be distinguished by genetic testing. Because of these similarities both species were treated the same for the biosecurity response and given 'Unwanted Organism' status by the Chief Technical Officer (CTO) of MPI. But as will be explained later this assumption is no longer valid.

While the source of this introduction into New Zealand is still unknown it is likely to have been introduced on fishing or boating equipment, such as an anchor or anchor chain. Given the main entry port for boats coming into New Zealand is Opuia in the Bay of Islands, and exotic caulerpa was later detected in Omakiwi Bay at Te Rāwhiti¹⁸, exotic caulerpa may have first been introduced here, then later spread by boat to Aotea/Great Barrier Island.

Although both species are present at Aotea/Great Barrier and the Bay of Islands just *C. parvifolia* is present at Ahuahū/Great Mercury, Waiheke and Kawau (Iris shoal), which raises the question as to whether there was more than just one introduction of exotic caulerpa into New Zealand.

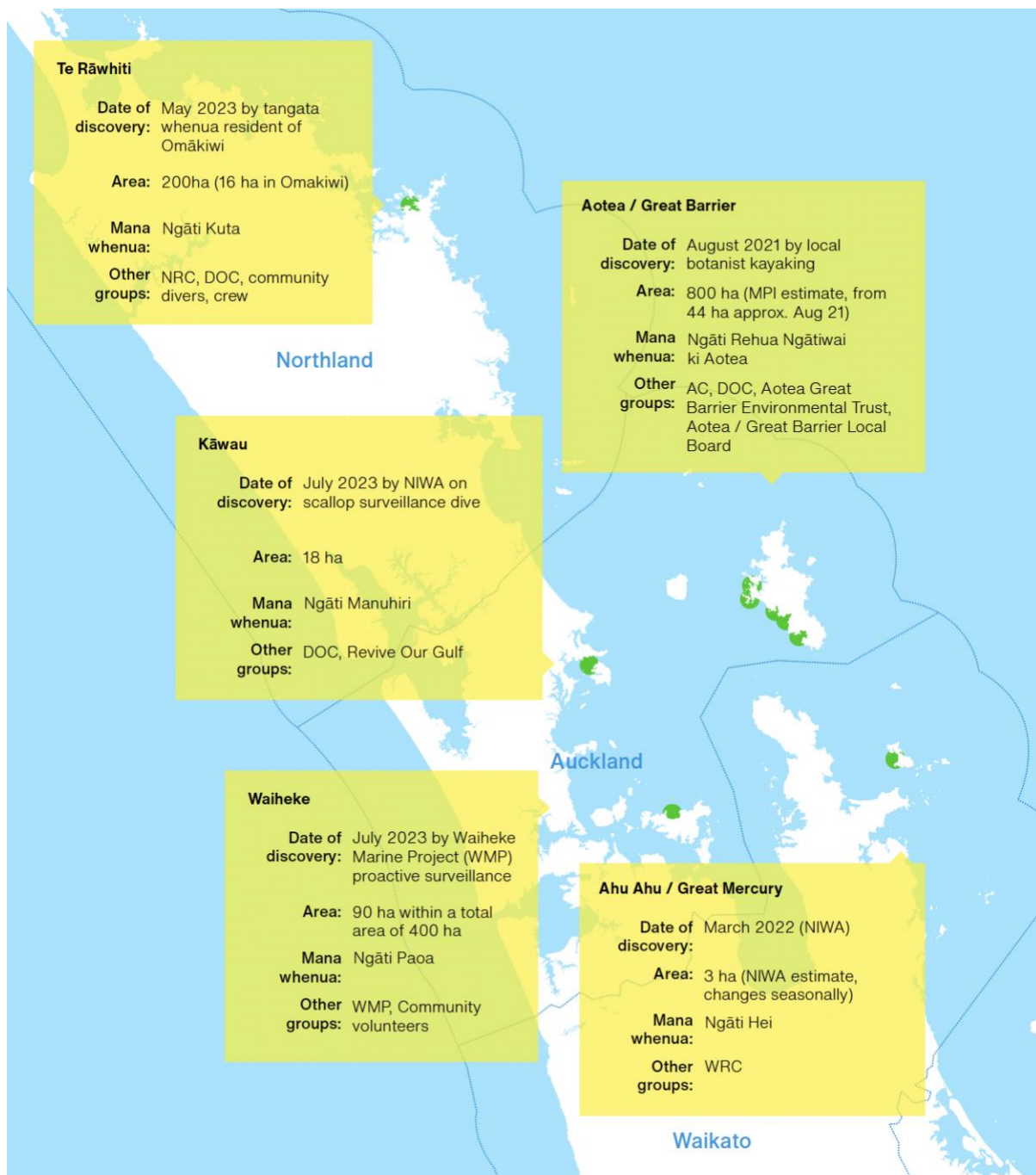
¹⁵ Belton, G.S., Huisman, J.M. & Gurgel, C.F.D. (2015). Caulerpaceae. In: Algae of Australia: marine benthic algae of north-western Australia. 1. Green and brown algae. (Huisman, J.M. Eds), pp. 75-102. Canberra & Melbourne: ABRS & CSIRO Publishing.

¹⁶ Belton, G.S., Draisma, S.G.A., Prud'homme van Reine, W.F., Huisman, J.M., Gurgel, C.F.D. (2019) A taxonomic reassessment of *Caulerpa* (Chlorophyta, Caulerpaceae) in southern Australia, based on *tufA* and *rbcL* sequence data. *Phycologia*, 58(3): 234-253. 10.1080/00318884.2018.1542851

¹⁷ BNZ newsletter update to the community - Update 3, 4 November 2021.

¹⁸ Exotic caulerpa found in Bay of Islands. <https://www.rnz.co.nz/news/ldr/491608/north-island-councils-combine-in-urgent-call-to-govt-for-caulerpa-support>

Figure 3: Map of affected areas from *Briefing to Incoming Ministers*



The biology of *C. brachypus* and *C. parvifolia*

Caulerpa is one of the most widespread and diverse green macroalgal groups found worldwide, with around 100 species currently recognized. Southeast Asia, Australia and the Caribbean are regions where there is high diversity. While there is considerable morphological diversity across the genus the general growth form comprises a horizontal stolon (or rhizome) with erect green photosynthetic fronds, and colourless rhizoids that anchor the alga to both soft and hard seabed surfaces. The name *Caulerpa* is derived from the Greek words *kaulos*

(stalk) and *herpo* (to creep). A distinct feature of the group is their single celled, multinucleate (coenocytic) cellular makeup, making them among the biggest single cells in the world. They generally reproduce by fragmentation of vegetative tissue but there are marked differences among *Caulerpa* species in their ability to produce fragments and in the ability of the different tissue fragments to regrow. For *C. brachypus* and *C. parvifolia* we still have limited knowledge of the fragmentation rates, fragment dispersal rates and the ability of fragments to regrow, but it is clear from how rapidly they spread within Tryphena and Whangaparapara harbours between September and December of 2021, and the subsequent spread along the western coast of Aotea, that fragmentation, dispersal on currents and regrowth are all occurring at a high rate despite this seaweed being 'negatively buoyant'. The observation that the exotic caulerpa is forming 'floating balls' may be one of the reasons for the high rate of dispersal (see below).

Some species of *Caulerpa*, such as *C. racemosa*¹⁹ and *C. taxifolia*²⁰, are known to have a sexual cycle, but there are no reports to date of sexual life cycles for either *C. brachypus* or *C. parvifolia*. The ability to sexually reproduce generates more diversity within a species and the ability for that species to more readily adapt to a new environment.

Many species of *Caulerpa* produce sesquiterpene toxins such as caulerpenyne and other phytochemicals, which are known to inhibit the growth of many marine animal and plant species²¹. Whether *C. brachypus* or *C. parvifolia* produce these toxins is as yet unknown but is the subject of a current study by NIWA in collaboration with the University of Auckland²².

Growth rates and spread

While we have no direct measurements of the growth rates of *C. brachypus* and *C. parvifolia* in New Zealand waters, experiments are underway by researchers at the University of Auckland to fill this important knowledge gap. However, the spread of exotic caulerpa between September and December of 2021 from 10 to 1750 sq m in Whangaparapara Harbour, and from 0.01 to 1840 sq m in Tryphena Harbour, suggest the growth rates are very high²³. It is this very characteristic of exotic caulerpa that makes it such a serious marine pest species and why it is on a 'watch' list by many countries. Growth rates of between 0.4 to 1.8 cm per day have been reported from *in situ* measurements in the Mediterranean of seven different species of *Caulerpa*²⁴. Researchers in California reported a growth rate of 1.3 cm per day for *C. taxifolia*²⁵. Assuming a radial growth rate of 1 cm per day, a one sq m patch of exotic caulerpa will grow to 10 sq m in a period of 4 months, highlighting the need to respond quickly to new incursions.

¹⁹ Panayotidis P & Žuljević A (2000). Sexual reproduction of the invasive green alga *Caulerpa racemosa* var *occidentalis*. *Oceanologica* 24: 199-203.

²⁰ Žuljević, A., Antolić, B. (2000) Synchronous release of male gametes of *Caulerpa taxifolia* (Caulerpales, Chlorophyta) in the Mediterranean Sea. *Phycologia*, 39(2): 157-159. 10.2216/i0031-8884-39-2-157.1

²¹ Rushdi et al. (2020). A review of the diversity, chemical and pharmacological potential of the green alga genus *Caulerpa*. *South African Journal of Botany* 132: 226-241.

²² Jessica Scarrott (2024). MSc thesis, University of Auckland (in preparation).

²³ BNZ newsletter update to the community - Update 5, 20 December 2021.

²⁴ Williams et al. (1985). Growth and sediment disturbance of *Caulerpa* spp. (Chlorophyta) in a submarine canyon. *Marine Ecology Progress Series* 21: 275-281.

²⁵ NOAA Fisheries report on *Caulerpa* species on the West Coast

As discussed above it is the ease with which exotic caulerpa fragments, as well as its fast growth rate, that enables such rapid spread. Besides ocean currents and boatgear (e.g. anchor and anchor chain), other vectors for spread may include scallops, and even snapper²⁶, but further studies are required to confirm whether this is the case or not. Commercial trawling and dredging on the seabed for fish is also likely to be a major vector for dispersal of exotic caulerpa. Despite the destruction this practice causes to the marine life on the seabed this practice continues, and to date has not figured prominently in the exotic caulerpa risk management toolbox.

Benthic mat/rock salt treatment trial

In December 2021, NIWA, under contract to Biosecurity New Zealand, travelled to Aotea/Great Barrier to treat the patches of exotic caulerpa detected in Whangaparapara and Tryphena Harbours in September 2021 with rock salt. Salt had been used previously to successfully manage the spread of *C. taxifolia* in NSW, Australia^{27,28}. However, because of the increased growth that had occurred in both harbours since their initial visit three months previously, they were unable to treat the entire area. A decision was made to treat 12 sq m in each harbour to test the effectiveness of the treatment method. A thick covering of salt was applied at each site and covered with either hessian or tarpaulin mats²⁹. While the method proved to be effective as a treatment method for small areas³⁰, the logistics of scaling this up to large areas precluded its use for treating the 'meadows' of exotic caulerpa found in Okupe/Blind Bay. No alternative methods were tried leaving exotic caulerpa to grow and spread³¹.

On this same visit NIWA carried out additional dive surveillance at:

1. Motairehe/Katherine Bay – 6 dives (all negative)
2. Whangaparapara – 5 dives (just one positive for exotic caulerpa)
3. Tryphena – 5 dives (all negative)
4. Port Fitzroy – 8 dives (all negative)
5. Smokehouse Bay – 2 dives (both negative)
6. Nagel Cove - 2 dives (both negative)

All surveillance was carried out by divers along pre-determined linear transects and did not include remote operating vehicles (ROVs). A specific part of their brief was not to remove any exotic caulerpa they came across during the surveillance. At some time in 2022 NIWA changed their surveillance to a star transect methodology³².

²⁶ <https://inaturalist.nz/observations/202134414>

²⁷ Creese et al. (2004). Eradicating and preventing the spread of the invasive alga *Caulerpa taxifolia* in NSW. NSW Fisheries Final Report Series No. 64. ISSN1440-3544.

²⁸ Glasby et al. (2005). Experimental use of salt to control the invasive marine alga *Caulerpa taxifolia* in New South Wales, Australia. *Biological Conservation* 122: 573-580.
<https://www.sciencedirect.com/science/article/abs/pii/S0006320704004124>

²⁹ BNZ newsletter update to the community - Update 5, 20 December, 2021.

³⁰ BNZ newsletter update to the community - Update 7, 28 January, 2022.

³¹ Barry Scott (2023). Editorial: Exotic caulerpa incursion: a monumental failure in marine surveillance and biosecurity preparedness. *Environmental News*. Issue 48. Winter 2023. Pages 1-7.

³² BNZ newsletter update to the community – 20 April 2022.

Technical Advisory Group Report

In October 2021, Biosecurity New Zealand set up a *Caulerpa* Technical Advisory Group “to provide independent, expert scientific and technical advice on methods/tools (particularly where these methods may be new or emerging) to manage exotic *Caulerpa* at Aotea GBI.” This report, dated 3rd February 2022³³, only became publicly available in 2023 through an Official Information Act request (with author names redacted). It can now be downloaded from the Biosecurity New Zealand web site³⁴.

The key conclusions and recommendations of this report were:

- The scale of the incursion is far beyond that at which successful eradication has ever been achieved in marine environments internationally.
- Eradication within each infected area is also not possible with the current set of tools available.
- It is extremely difficult to define the extent of the entire population on GBI. Therefore, it is highly likely some will be missed, if the treatment used is non-selective (kills everything) the bare substrate will be ideal habitat for exotic *Caulerpa* recolonisation.
- At small scale coarse salt appears to be the most practical and cost-effective method for local elimination and suppression currently available.
- The best we can aim for with the current tools is suppression and containment.
- The most effective treatment programme will likely have to combine a range of treatment options.
- Exotic *caulerpa* will require a long-term management plan to limit further spread.
- Research is required to develop/expand/adapt tools that can work at larger scales in the aquatic environment and that are targeted to specific organism types (e.g., seaweed).
- Ecological research, in addition to tool development research, is required to determine the environmental tolerances and impacts of exotic *Caulerpa* in a New Zealand context.

A major oversight/omission from this report was the failure to include among the nine treatment methods considered, ‘diver directed suction dredging’ as an option for removal of exotic caulerpa from the seabed. This was the primary method used by the Southern Californian *Caulerpa* Action Team (SCCAT) for the successful removal of *C. prolifera* from Newport Bay, near Los Angeles, in 2021³⁵. This followed the eradication of *C. taxifolia* from Agua Hedionda Lagoon and Huntington Harbor using a combination of benthic mats and hand

³³ Biosecurity New Zealand, Technical Advisory Committee report. *Caulerpa* Great Barrier Island 2021 Response. February 2022, Published by MPI, Wellington.

³⁴ <https://www.mpi.govt.nz/dmsdocument/60280-Technical-Advisory-Report>

³⁵ Southern California *Caulerpa* Action Team (2021). Rapid response and eradication plan for the invasive green alga *Caulerpa prolifera* in Newport Bay.

removal over a six-year period from initial detection in 2000 to declaration of eradication in 2006^{36,37, 38}.

2022, a year of inaction

Apart from the tightening of some of the rules around the CAN, establishment of an on-island ambassador programme over the summer to help make the public and boating community aware of the threat of exotic caulerpa, and some surveillance, there was next to no action in the sea for most of 2022.

- 17 May: Biosecurity New Zealand led Hui held on Aotea.
- 20 July: Additional surveillance carried out by NIWA in response to reports from the community that exotic caulerpa had spread north of Whangaparapara.
- Exotic caulerpa was found at:
 - Three sites north of Whangaparapara including, Beacon Point (depth of 23 m), French Bay and Mangati Bay, and
 - At one site south of Whangaparapara, at Walter Hill Bay
 - No exotic caulerpa was detected in Port Fitzroy.
- 12 August: The Caulerpa Governance Group recommended the CAN be physically extended from Cape Barrier in the south to the Grey Islands in the north, near the entrance to Port Fitzroy.
- 30 Sept: period of CAN extended for 3 weeks but no change was made to the boundaries.

Summer of storms

The summer of 2022/2023 was a summer of severe storms on Aotea and across the north and east of the North Island, triggered by warming oceans associated with the La Niña weather pattern. Around seven major storms hit Aotea including cyclones Hale (10th January 2023) and Gabrielle (12-14th February, 2023). As Gabrielle moved south severe westerly winds ripped up the exotic caulerpa from the seabed of Okupe Bay and threw up around 50-100 tonnes of it onto the beach (Figure 4). This was a very confronting scene for the local community and increased the level of outrage over the inaction by both national and regional government on this very serious marine invasion. The discovery of exotic caulerpa at Omakiwi Bay by Te Rāwhiti environmental restoration and pest control specialist Rana Rewha (Ngāti Kuta) triggered further outrage from the communities around the Bay of Islands. The events and associated actions that followed on from this community concern are summarised in the attached timeline of events (Appendix 2). A key event was the public forum on exotic caulerpa at the June meeting of the Hauraki Gulf Forum where John Walsh (Director Readiness and Response Services, Biosecurity New Zealand, MPI) announced that “nothing was off the

³⁶ Steering Committee of the Southern California Caulerpa Action Team. February 2005. Southern Californian *Caulerpa taxifolia* eradication program. *Caulerpa taxifolia* survey efficacy assessment at Agua Hedionda lagoon and Huntington Harbour.

³⁷ Steering Committee of the Southern California Caulerpa Action Team. May 2006. Final report on the Eradication of the invasive seaweed *Caulerpa taxifolia* from Agua Hedionda lagoon and Huntington Harbour, California.

³⁸ San Diego Regional Water Quality Control Board (2006). Eradication of destructive, invasive, non-native seaweed announced.

table.” To estimate what was at stake economically, the Hauraki Gulf Forum commissioned a study from the New Zealand Institute of Economic Development who estimated that the natural capital value of the Hauraki Gulf was between \$40-100 b with around \$5b per annum³⁹.

Figure 4: Exotic caulerpa on Okupe Beach after Cyclone Gabrielle (Noel Nancekivell).



In terms of action on Aotea two major things happened:

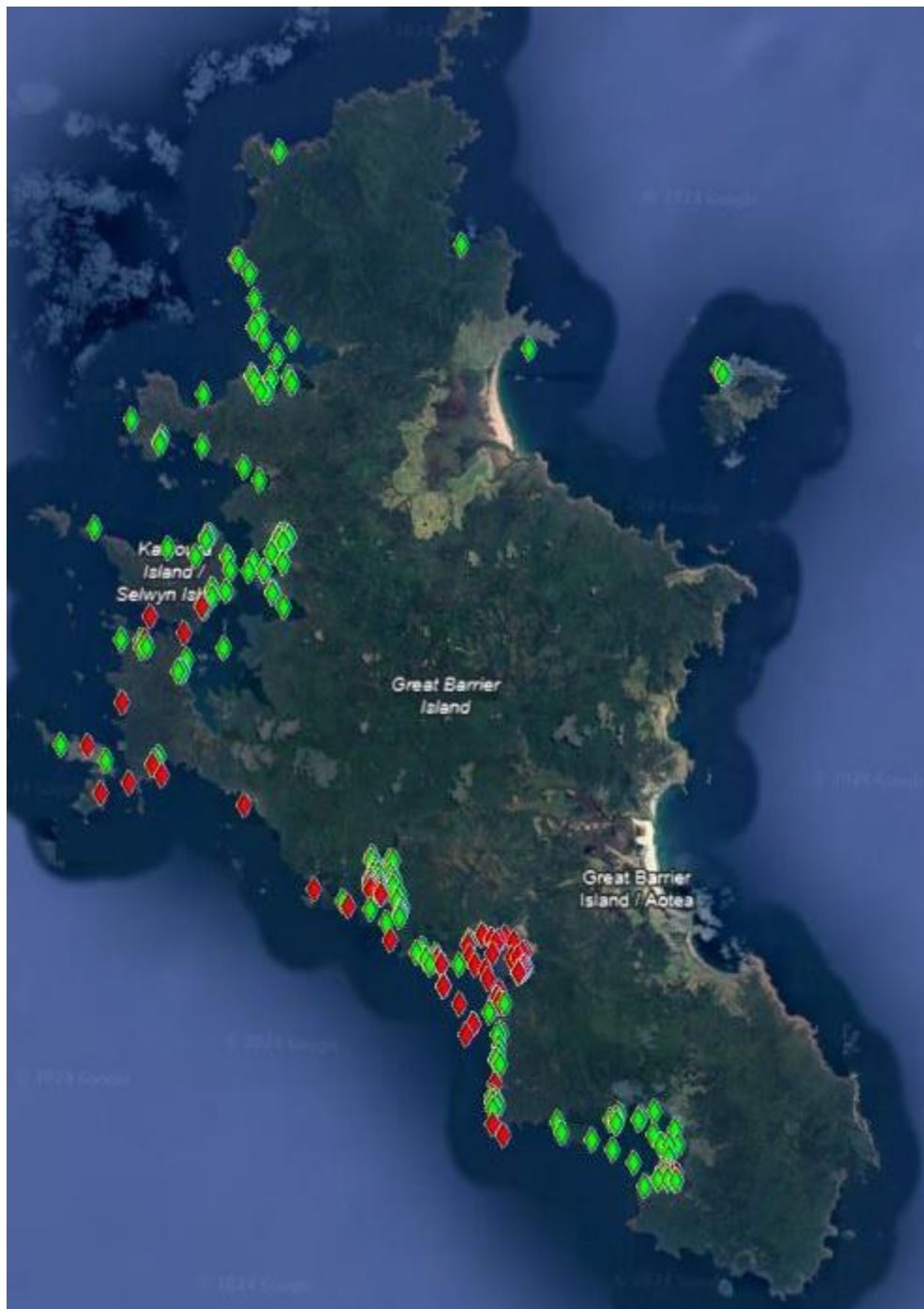
1. Additional surveillance was carried out by NIWA under contract from Biosecurity New Zealand in July of 2023, and
2. A suction dredge trial was carried out in Tryphena harbour in September of 2023, following release of the Exotic Caulerpa Suction Dredge Technical Advisory Group in July 2023.

NIWA surveillance at Aotea, July 2023

Given no surveillance had been carried out on Aotea for a period of a year it was no surprise to find exotic caulerpa had spread over that time, especially given the major storms of the summer of 2022 and 2023. Dive transect surveillance was carried out by NIWA over 4 days from the 22 July 2023. Situation reports 5, 6, 7 and 8 describe the results of that surveillance (**Appendices 3-6**). Exotic caulerpa was found in Bowling Alley, at three sites around Motu Kaikoura, including two within Port Fitzroy, one at the entrance of the Man of War Passage (BRO144) and one in an eastern bay of Motu Kaikōura (FITZ 151). All other transects checked within Ports Fitzroy and Abercrombie, Katherine Bay, Rangiwahakaea, Okiwi Bay, Whangapoua and Arid cove on Rakitū were negative.

³⁹ Our \$100b natural capital asset: the Hauraki Gulf Marine Park, Tikapa Moana, Te Moananui-ā-toi by Alex Rogers (July 2023). <https://gulfiournal.org.nz/2023/07/natural-capital-valuation/>

Figure 5: Map of NIWA dives 2021 to 2023



A summary of the surveillance carried out is outlined below:

- Report 5 (22 July, 2023): ROV (Boxfish) search in deep waters at Schooner Bay but too rough. Carried out dive transects at Bowling Alley (BOW142 & BOW147), Mahuki Island (BRO138 & BRO139) and Schooner Bay (ROV134, ROV135 and ROV136) – all positive.
- Report 6 (23 July, 2023): Dive transects were carried out through the Brokens (BRO140, 141,143, 144 & 148; all sites positive except BRO140) and Port Fitzroy (FITZ149-151,

FITZ154-155; all negative except FITZ151) and Port Abercrombie (ABC152, 153 & 157; all negative).

- Report 7 (24 July, 2023): Dive transects were carried out in Port Abercrombie (ABC158, ABC156, MOT172), Katherine Bay (MOT164-MOT171), Rangiwahakaea Bay and Okiwi Bays (ARI159-160) – all negative.
- Report 8 (25 July, 2023): Dive transects were carried out at Rakitu (ARI161-163) and again within Port Fitzroy (FITZextra1-3) – all negative.

Note: the convention used is NIWA specific and is different to that used by Logan Marine, highlighting the need for a national portal where all surveillance data is logged including date, GPS coordinates, depth etc.

Technical Advisory Group Report

In June 2023, Biosecurity New Zealand set up an Exotic Caulerpa Suction Dredge Technical Advisory Group “to advise on the utility of suction dredging in the Aotearoa caulerpa response.” The key conclusions and recommendations from this TAG⁴⁰ were:

1. Suction dredging should be trialled immediately to acquire more information on the Aotearoa context and to inform a broader exotic caulerpa management strategy.
2. Suction dredging could be one of many useful tools to manage exotic caulerpa in Aotearoa, but a trial is essential to understand its utility here.
3. Suction dredging is likely to be effective at reducing the biomass of large infestations of exotic caulerpa.
4. It is likely that suction dredging would not achieve total removal of exotic caulerpa. If the aim of a biosecurity response is local elimination or eradication, suction dredging may need to be combined with other methods, such as mats or hand removal.
5. Caulerpa management is multiyear, and it is important to take an intergenerational view of ecological restoration.
6. Two suction dredging trials are recommended: one on the mainland and one in a remote location.

These recommendations were adopted by MPI with suction dredge trials carried out on Aotea in September 2023 and in Te Rāwhiti in February 2024.

Suction Dredge Trial in Tryphena Harbour

In September 2023 Biosecurity New Zealand contracted Bay Underwater Services NZ Ltd, under the guidance of NIWA, to carry out a diver directed suction dredge trial in Tryphena Harbour. Over a period of 10 days (18-28th Sept) an area of 1200 m² was dredged in Shoal, Puriri and Schooner Bays with around 17 tonnes of exotic caulerpa removed. Benthic mats together with hypochlorite tablets were also used to determine the effectiveness of this method. On the final day of their visit to Aotea they dredged two sites in Port Fitzroy (FITZ151 and BRO144) to clear them of exotic caulerpa in response to community concerns about the

⁴⁰ Exotic Caulerpa Suction Dredge Technical Advisory Group Report. Biosecurity New Zealand Information Paper No. 2023/03. ISBN No: 978-1-991087-30-0 (online). ISSN No: 2624-019X (online). <https://www.mpi.govt.nz/dmsdocument/58177-Exotic-Caulerpa-Suction-Dredge-Technical-Advisory-Group-Report>

large numbers of boats anticipated to visit the Port over the Summer of 2023/2024. Two follow up visits were carried out by NIWA to monitor and analyse the effectiveness of the trial in October and December of 2023. As of March 2024, the pre- and post-dredge trial reports have still not been released by Biosecurity New Zealand. The budgeted cost for this project was \$918,890.35.

Impact of exotic caulerpa on marine ecosystems at Aotea

Given how recent this incursion has been it is still very difficult to determine the impact on the marine ecosystems at Aotea. Exotic incursions are often unpredictable and frequently unstoppable without very early intervention. While a long-term study is underway by NIWA on the impact of exotic caulerpa on the marine ecosystems of the three affected Aotea western bays, it may take many years before definitive scientifically conclusions are reached. However, community observations are providing a useful insight into the immediate effects. Close examination of samples from the caulerpa mats has shown that these mats are almost completely devoid of any resident native organisms⁴¹. Very useful insights have also been provided through the Ahu Moana project⁴². Overseas studies also provide important insights as to what might happen in New Zealand.

Overseas research

It is very clear from overseas studies that exotic caulerpa has had major impacts on the flora and fauna (both vertebrates and invertebrates) at those sites both above and below the seabed. This is why many countries around the world have exotic caulerpa on their watch list of potential invasive species. The main impacts come from competition and habitat modification. In a six-year study of the impact of *C. taxifolia* on the marine life in the Mediterranean, Harmelin-Vivien et al (1999)⁴³ found that there was a “a significant decrease in species richness (23-31%), mean density (31-36% and mean biomass of fish (42-57%) occurred in sites colonised by *C. taxifolia* compared to reference sites”. The potential impact of exotic caulerpa on fisheries is an issue highlighted in several other publications and reports including the USA *National Management Plan for the Genus Caulerpa*^{44,45}.

Local observations

It is difficult not to reach the conclusion that the dense mats of exotic caulerpa found in Okupe Bay and elsewhere, that resemble ‘AstroTurf’, are having a significant impact on the marine flora and fauna at these sites (Figure 5). These mats occupy most of the seabed space and

⁴¹ Thomas Daly and Craig Thorburn (personal communication).

⁴² Glenn Edney (2024). The Ahu Moana Vision. Environmental News, Issue 49, Summer 2024.

⁴³ Harmelin-Vivien M., Francour P. and Harmelin J.G. (1999). Impact of *Caulerpa taxifolia* on Mediterranean fish assemblages: a six year study. In: UNEP (ed) Proceedings of the Workshop on Invasive Caulerpa species in the Mediterranean, Heraklion, Crete, Greece, 18–20 March 1998, MTS 125, UNEP, Athens, Greece, pp. 127–138.

⁴⁴ Aquatic Nuisance Species Task Force (2005). National management plan for the genus *Caulerpa*. A report prepared by a *Caulerpa* Working Group under the auspices of ANSTF.

<https://static1.squarespace.com/static/5339e6f9e4b061857996f939/t/64a4d7f65defb4567d29835d/1688524813611/CWG++National+Management+Plan+for+the+Genus+Caulerpa.pdf>

⁴⁵ Federal Register Vol 70, No. 158, August 17, 2005. <https://www.govinfo.gov/content/pkg/FR-2005-08-17/pdf/05-16244.pdf>

therefore prevent other seaweeds from growing and thriving. Close examination of samples from these mats has revealed next to nothing growing among or below the 'AstroTurf', highlighting the seriousness of the impact. The mats of caulerpa are also very likely to change dramatically the invertebrate fauna of the seabed and the fish that graze at these sites. Where the infestations are less dense such as on rocky reefs the impacts may be less severe.

Figure 6: *C. brachypus* from Okupe Bay showing AstroTurf like structure (Izzy Fordham) NIWA research



In 2022 NIWA was awarded a research contract from MPI to study the ecological impacts of exotic caulerpa on native species at Aotea/Great Barrier Island. For this study 18 transects, six in each of Whangaparapara, Okupe and Tryphena harbours, were set up at Aotea for long term monitoring of ecological changes at each of these sites. The first report on this study was submitted to Biosecurity New Zealand in April 2023 but did not become available to the community until October 2023⁴⁶. While most of the findings are preliminary, and therefore difficult to make conclusions that establish causation, high mortality of scallops was observed at sites where there was a high density of caulerpa. We also understand that NIWA found that the scallop beds on the Iris Shoal at Kawau were heavily infected with caulerpa. A second research report was submitted by NIWA to Biosecurity New Zealand in November 2023, but this has not yet been released to the community (as of March 2024).

⁴⁶ Caulerpa 2023. Impact of exotic caulerpa on native species at Aotea/Great Barrier Island – Phase 1 . Prepared for Biosecurity New Zealand. April 2023.
<https://www.mpi.govt.nz/dmsdocument/58228-Caulerpa-2023-Impact-of-exotic-Caulerpa-on-native-species-at-AoteaGreat-Barrier-Island-Phase-1>

Figure 7: Floating balls of *Caulerpa* (Glenn Edney)



Ahu Moana

The Ahu Moana vision of local management of marine ecosystems was developed as part of the *Sea Change – Tai Timu Tai Pari*, New Zealand’s first marine spatial plan, which was launched in 2017 for the Hauraki Gulf. It is one of the core elements of the Government’s 2021 ‘Revive the Gulf’ strategy. It is based on four main pillars: people, place, knowledge, and action. It brings together Tangata whenua and local community and uses their combined knowledge and skills to deliver shared goals in local fisheries and environments. The Ahu Moana Pilot project on Aotea is being conducted under the auspices of Ngāti Rehua Ngātiwai ki Aotea Trust and the Aotea Local Board and is led by marine ecologist Glenn Edney. The Hauora Moana survey method being used has been developed specifically for communities to help them assess the current state of health of their marine ecosystems. It uses a combination of ecological and environmental indicators, as well as specific species that are important to the community. While exotic caulerpa is one of the indicators, the primary purpose of the survey is to build knowledge about the overall state of the ecosystem. But importantly these surveys provide additional ‘eyes in the water’ as to what is happening with exotic caulerpa and its impact on native ecosystems within the sites being surveyed, which include Schooner and Katherine Bays at Aotea. To date a total of 8 survey dives have been conducted within Schooner Bay along two different lines that finish at Titi Islands and Turi Point, respectively. One of the most dramatic changes they have observed is the recovery of kōura within this short period of time because of the ‘no diving’ restriction within the CAN

since August 2021⁴⁷, but that recovery will be short lived given diving restriction were removed by MPI when the new CAN was put in place in December 2023. Exactly when exotic caulerpa started colonising Schooner Bay is unclear, but we know it was absent in the summer of 2021/2022 (observation by resident Josh Knight) but was spread throughout the Bay by October 2022 when the first Ahu Moana survey was carried out. In the most recent survey (February 2024), the team were shocked to find large ‘floating balls’ of unattached exotic caulerpa drifting in Boyd’s Bay. Such large masses of exotic caulerpa pose a very high risk for spread outside the bay by ocean currents or by attachment to boat or fishing gear.

The power of environmental DNA (e-DNA)

In November 2020 marine and freshwater samples from Okupe Bay were collected by a community member at Okupe and submitted by Michael Bunce (then at EPA) for environmental DNA (e-DNA) analysis using the services of Wilderlab in Wellington⁴⁸. Following discussions with Barry Scott and Kate Waterhouse (AGBET) in December 2023, Michael asked Wilderlab to carry out a retrospective analysis of the samples using new assays that had become available for marine taxa, including *Caulerpa brachypus*. Strikingly, reads to *Caulerpa brachypus* were the highest of all the taxa analysed in the marine samples highlighting the potential power of this technique for marine surveillance⁴⁹. However, this is unlikely to be a useful surveillance method where there are just small patches of exotic caulerpa but that remains to be determined by running sensitivity assay tests at one of the infected sites. Had DNA sequences for *C. brachypus* been included in the Wilderlab data base when the samples were originally submitted, we would have been aware 8 months earlier (November 2020) than when this exotic species was first identified by Jack Warden in June 2021. Further research is underway to develop a sensitive and species-specific PCR test for the detection of exotic caulerpa in marine samples at the University of Otago⁵⁰.

Nov 2023 – Feb 2024 Surveillance at Aotea

In response to community concerns about the potential for boats visiting Aotea over the summer of 2023/2024 to further spread exotic caulerpa, AGBET pushed strongly for more intensive surveillance to be carried out to help inform MPI on where to place the boundaries for extension of the CAN to minimize this risk. The first of these surveys carried out by Logan Marine Projects Ltd was funded by AGBET and the subsequent surveys from December through to March 2024 were funded by MPI and Auckland Council. Seven surveys have been carried out, all using a Remotely Operated Vehicle (ROV), to capture video footage of the seabed and reef along a series of transects. Kaitiaki accompanied the boat on all surveys. These included:

- Survey 1, funded by AGBET, was carried out between 21-23 November 2023. 87 transects were completed around Port Fitzroy, with five sites identified as possibly containing exotic caulerpa.

⁴⁷ Glenn Edney (2024). The Ahu Moana Vision. Aotea Great Barrier Environmental News, Issue 49, Summer 2024, pages 6-11.

⁴⁸ Wilderlab. Discovery through DNA. Advanced lab testing services for environmental DNA monitoring. <https://www.wilderlab.co.nz>

⁴⁹ Wilderlab. eDNA sample report: <https://s3.ap-southeast-2.amazonaws.com/wilderlab.openwaters/reports/31ca4502b5453c91.html>

⁵⁰ Jonika Edgecombe PhD research with Prof Neil Gemmill (personal communication).

- Survey 2, funded by MPI and AC, was carried out between 1-3 December at Katherine Bay, Port Abercrombie and Port Fitzroy. 78 transects were completed. One potential positive in bay on eastern side of Motu Haku – see map prepared by Dimitri.
- Survey 3 on the 12th January 2024 was cut short due to gear failure. Just 12 transects were completed – a couple potential positives NE of Motu Haku.
- Survey 4 was carried out from 4-6 February 2024, at Wellington Heads (Abercrombie), Flat Island and Sandy Bay/Rabbit Island south of Tryphena. 92 ROV transects were completed with exotic caulerpa detected around the Western end of Motu Haku and at Sandy Bay and Rabbit Island in the South. Intensive surveillance was carried out at Motu Haku in response to a posting on iNaturalist⁵¹ by a marine biologist from San Francisco (Gail Wechsler) who was diving at this site. Lots of positives on northern and western side of Motu Haku; west of Nelson Island clear; very bad around Rangiahua and through channel with Mahuki Island; few positives around Motutaiko Island; very bad around Rabbit Island in the south and in Sandy Bay.
- Survey 5 was carried out from 16-18 February 2024, around Motairehe/Katherine Bay and up to the Needles. 81 ROV transects were completed. Sites around Port Abercrombie and Katherine Bay negative; few positives near Miners Head; Needles negative.
- Survey 6 was carried out from 9-11 March 2024. 120 ROV transects were completed. Had closer look around Ahuriri Point (one positive north of point), Southern end of Miners Head and Katherine Bay (negative); closer look around Motu Haku – a lot of caulerpa through channel between Motu Haku and Nelson Island; and Man of War Passage – quite a lot through Passage and in Oneura Bay/Red Cliffs Cove; peters out around Governor Pass as go into Port Fitzroy.
- Survey 7 was started on the 9 April and 40 transects were completed; however, the survey had to be abandoned due to gear malfunction. LMP are yet to deliver final data to AC. More caulerpa observed on Kaikoura side of Governor Pass and was less prevalent heading into Pt Fitzroy.

⁵¹ Gail Wechsler iNaturalist post on exotic caulerpa at Motu Haku on 7th January at depth of ~18 m. <https://inaturalist.nz/observations/195979283>

Figure 8: Whole island map showing information from survey 4 and survey 5 (markers: green negative, orange suspect, red positive)

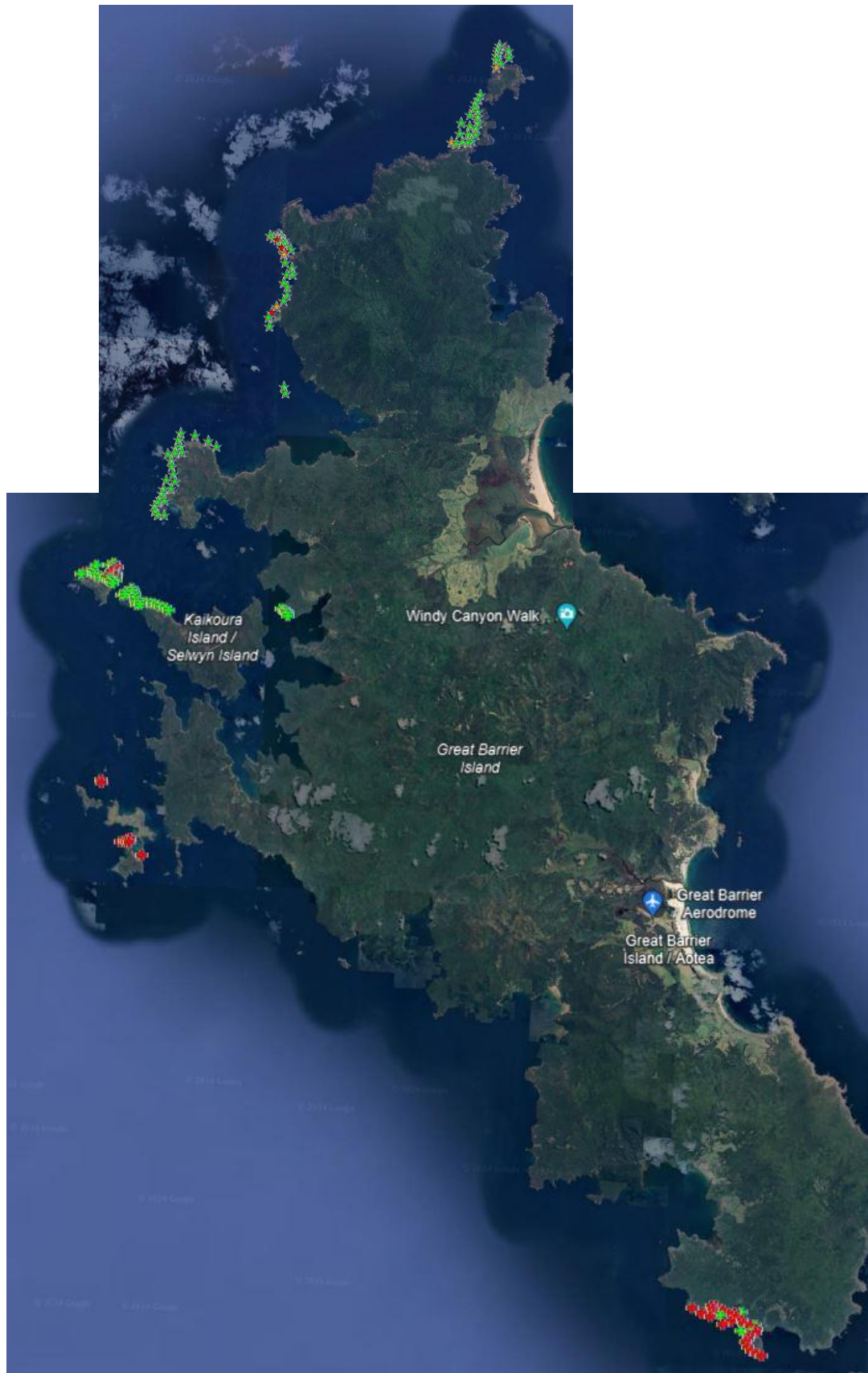


Figure 9: Detail map showing information from survey 6 (markers: green negative, orange suspect, red positive)



Ongoing surveillance at Aotea and restricting where boats can anchor is critical in reducing the risk of further spread of exotic caulerpa to mainland coastal systems. Because of the size of the infestation at Aotea, and the presence of the more invasive *C. brachypus* species, risk of spread from Aotea to the mainland is high unless this is carefully managed. To help manage this risk a summer Ambassador and on-water monitoring programme was set up at Aotea over the summer of 2023/2024. During the five-month period this programme was operating there were over 170 boats found to be in breach of the anchoring ban within the CAN. Some of those breaching this biosecurity order were repeat 'offenders'. AIS (automatic identification system) tracking of some of the boats that visited Aotea over the summer

highlighted the potential for exotic caulerpa spread if at some stage they were to anchor above an infected site. One 30 m superyacht was shown to sequentially anchor at Medlands, Hauturu O Toi/Little Barrier, Te Hāwere-A-Maki/Goat Island then return to Whangārei. While none of these sites are known to have caulerpa the AIS tracking really highlights how widely and rapidly exotic caulerpa could be spread to new sites (including known marine reserves), especially if the boat has a very large anchor and chain as superyachts do. For these reasons controlling the spread of exotic caulerpa at Aotea is vital not just for the island but for the marine ecosystems around the Hauraki Gulf and along the NE coast of the North Island.

Aotea Caulerpa Steering Committee

In response to the need to take urgent action in the waters of Aotea to stop the further spread of exotic caulerpa, a new Aotea-led response group, the *Aotea Caulerpa Steering Committee*, was set up March 2024. This new structure will be led by Ngāti Rehu Ngātiwai ko Aotea Trust in collaboration with the Local Board and the Aotea Great Barrier Environmental Trust (AGBET). Key activities of this group, working closely with the Auckland Council Biosecurity group, will be on-island surveillance for exotic caulerpa and action in the sea to kill or remove new pockets of exotic caulerpa detected outside the current CAN.

Knowledge gaps

As we set out to grow capacity and capability to control the spread of exotic caulerpa around Aotea it will be critical that we can draw on as much local, regional, national, and international knowledge and research as possible. Although there are many knowledge gaps some of these will be answered from work carried out on and off the island.

Tools for surveillance

Surveillance to date has been a combination of diver (NIWA) and remote operated vehicle (Logan Marine) surveys. We anticipate that in the near future surveillance will be on-island led using both of these methods as this approach will be a lot more cost effective and will utilize local knowledge of the marine topography and currents. Key knowledge and support systems important for quality surveillance include:

1. Online portal. Establishment of a portal for logging and viewing real time surveillance data for the Hauraki Gulf and the entire NE coast of the upper North Island. Surprisingly, such a system is still not up and running after almost three years into the incursion. The Biosecurity team at Auckland Council (led by Dimitri Colella, Senior Marine Biosecurity Advisor) are working closely with other regional councils, and with MPI (led by Graham Allen, Manager Marine Pest Management), to establish a surveillance portal, possibly as an add on to the current Marine Vessel Portal (ArcGIS hub based; **Note**: Hamish Lass from BOPRC historically led development of this portal).
2. Ocean currents. Knowledge of ocean currents around Aotea Great Barrier and how they change with seasons and with alternating weather patterns such as El Niño and La Niña will help inform where exotic caulerpa will be carried to and where to focus surveillance. Much of that knowledge will be available within the local community especially from those who spend a lot of time on the ocean. But information from others such Giovanni Coco (School of Environment, University of Auckland) who has

modelled microplastic distribution in the Hauraki Gulf may be useful⁵². The work he has done to date does not extend to Aotea so would require additional modelling.

3. Boat Movement. Analysis of boat movements from Automatic Identification Systems (AIS) has been shown to be a useful tool to identify high risk anchoring sites where surveillance should be carried out on a regular basis⁵³. This approach is being employed by Northland Regional Council.
4. Aerial surveillance. Exploratory work is underway as to whether use of an aerial drone in combination with light spectral analysis might be a useful tool to identify exotic caulerpa in the sea – more information from Peter Miles at *Revive Our Gulf*.
5. e-DNA surveillance. As discussed above this method has already been shown to be useful as a marine surveillance tool but the sensitivity and general utility of this method has still to be evaluated. There are also important issues around data sovereignty, which has been the topic of considerable recent discussion. A Te Tiriti-guided national DNA reference library wananga series was recently run by Manaaki Whenua/Landcare Research in collaboration with New Zealand’s Biological Heritage (National Science Challenges)/Nga Koiora Tuku Iho⁵⁴.
6. Data management. ROV-based benthic imaging will capture video footage of all marine life across the transects surveyed. Key questions to be addressed are who owns that data and what data should be released into the public domain. Data such as kōura nurseries and pāua beds, should be protected so that further exploitation of an already threatened species is protected. A discussion paper on data sovereignty was recently released by Royal Society Te Apārangi⁵⁵.
7. Improved ROV surveillance. Ocean Infinity uses ROV and side-scan sonar for scanning wider areas of the seabed⁵⁶.

Tools for controlling, killing and/or removing exotic Caulerpa

The most effective methods for killing exotic caulerpa *in situ* are the use of benthic mats⁵⁷. Rock salt treatment has also been used but benthic mats have been found to be more effective, especially in combination with hypochlorite pellets. A trial on the use of benthic mats to kill exotic caulerpa was carried out by NIWA, under contract from MPI, in September of 2023 in Tryphena Harbour, but the report on this trial has not yet been released.

The most efficient and cost-effective method for removing exotic caulerpa is by diver directed suction dredging. This method was used successfully as a first stage in the eradication of C.

⁵² <https://www.moanaproject.org/hindcast>

⁵³ Floerl O, Hilliam K, Faubel C, Stevenson S and Trembl E (2023). Prioritising surveillance sites for exotic caulerpa in Northland, Cawthron Institute Report No. 3952. Prepared for Northland Regional Council. Note: the lead author on this study, Oliver Floerl, now is with a private company called *Land Water People*.

⁵⁴ A Te Tiriti-guided national DNA reference library wananga series. Manaaki Whenua/Landcare Research. <https://www.landcareresearch.co.nz/events/national-dna-database-webinar-series/>

⁵⁵ Royal Society Te Apārangi (2023). Mana Raraunga Data Sovereignty - ISBN: 978-1-877264-57-3 (digital); ISBN: 978-1-877264-58-0 (print); 60 pages.

⁵⁶ <https://oceaninfinity.com>

⁵⁷ Steering Committee of the Southern California Caulerpa Action Team. May 2006. Final report on the Eradication of the invasive seaweed *Caulerpa taxifolia* from Agua Hedionda lagoon and Huntington Harbour, California.

prolifera from Newport Harbour in California⁵⁸. A trial was carried out by NIWA and Bay Underwater Services, under contract from MPI, in September of 20023 in Tryphena Harbour, but the report on this trial has not yet been released. A second trial has been carried out in Omākiwi Cove, by Northland Regional Council and Te Rāwhiti hapu, Ngāti Kuta and Ngāti Patukeha, in collaboration with MPI, but the report on this trial has not yet been released. For this trial the head of the dredge was controlled remotely from the barge. Work is ongoing by Johnson Bros. from Ōpua to refine this method.

The method(s) deployed to remove exotic caulerpa will be very dependent on site topography, seabed composition (sand or rocky reef), ocean depth, ocean currents and a number of other variables. Among these, ocean depth is probably the most important given divers are limited to free diving to depths of around 6-12 m and can only stay at greater depths for limited periods of time. Given exotic caulerpa has the potential to grow to depths of around 40 m and has been observed growing at depths of around 30-35 m at Aotea (reference?), makes removal at these sites particularly challenging.

Sources for further information on these and other potential methods for killing or removing exotic caulerpa are listed below:

1. Webinar on exotic caulerpa removal. There is an excellent webinar by Rachel Woodfield on methods successfully employed by SCAAT in California to remove exotic caulerpa from lagoons and bays⁵⁹.
2. Woollen carpet benthic mats. Ngāti Paoa are currently trialling the use of woollen carpet from Bremworth NZ as an alternative to synthetic mats/tarpaulins. The carpets are woven with dark or brown wool to maximise absorption of light to generate heat under the mat to kill the exotic caulerpa.
3. UV-C treatment. Craig Thorburn (Waiheke Marine Project) and Andrew Jeffs (University of Auckland) are currently investigating whether UV-C treatment of exotic caulerpa might offer an alternative method for control in the ocean. Results to date are promising.
4. Kina for biocontrol of caulerpa. Biosecurity New Zealand has commissioned Auckland University of Technology (AUT) to undertake laboratory-based trials on the potential of kina as an augmentative biocontrol agent for exotic caulerpa. Ahu Moana is also examining whether kina, confined to cages, feed exotic caulerpa in Schooner Bay.

Disposal of Exotic Caulerpa

Exotic caulerpa can be disposed on land by compositing or burial. A study was carried out in 2023 by Agrisea under contract from MPI to test whether exotic caulerpa could be used for two different commercial uses. The cell wall of caulerpa is comprised principally of hemicellulose with little to no cellulose, limiting its use for structural purposes. Given the cost associated with disposal, more cost effective methods need to be explored.

Biology of Exotic Caulerpa

⁵⁸ Southern California Caulerpa Action Team (2021). Rapid response and eradication plan for the invasive green alga *Caulerpa prolifera* in Newport Bay.

⁵⁹ <https://www.youtube.com/watch?v=9QmwIJYBFNo>

1. Two species. Observations by Craig Thorburn suggest *C. parvifolia* is behaving very differently to *C. brachypus* at Waiheke⁶⁰. It appears *C. brachypus* grows and spreads much faster than *C. parvifolia* and is much harder to control. *C. parvifolia* grows slower, and prefers cooler waters to *C. brachypus*, so may be easier to control. The apparent lack of spread of *C. parvifolia* at Ahuahu/Great Mercury (between Paritu and Pukekoromikio Points) supports this hypothesis. More research is needed, but observations so far strongly suggest that at a national management level the two species should be treated differently and not assumed to be the same as first thought.
2. Marine Flora and Fauna. The marine flora of Aotea is still rather poorly studied (*personal communication* Wendy Nelson). There is potential for loss of species as a result of the current incursion highlighting the need for a more extensive survey of the coastal waters around Aotea.

Figure 10: Comparison of *C. brachypus* with *C. parvifolia* (Craig Thorburn).



Additional funding for control of exotic caulerpa in New Zealand waters

In March 2024 the Minister for Biosecurity, Andrew Hoggard, announced a \$5 million boost to boost removal methods for controlling the spread of exotic caulerpa⁶¹. Despite the magnitude of the infestation at Aotea, just \$200 K of the \$5m has been allocated to control at Aotea.

⁶⁰ Craig Thorburn (personal communication).

⁶¹ <https://www.beehive.govt.nz/release/government-boost-fight-against-caulerpa>

Appendix 1

Timelines from Biosecurity Newsletters

2021

- #1 1 Oct: CAN put in place for Tryphena and Okupe on 20th Sept.
- #2 15 Oct: CAN extended to Whangaparapara on 16th Oct.
- #3 4 Nov: DNA analysis showed that *Caulerpa* species in Whangaparapara is *C. parvifolia*; just *C. brachypus* in Okupe, and both species in Tryphena.
- #4 2 Dec: legal controls associated with the CAN.
- #5 20 Dec: rock salt applied (and covered with hessian or tarpaulin mats) to 12 sq m sites in Tryphena and Okupe early Dec; between September and December of 2021 exotic caulerpa grew from 10 to 1750 sq m in Whangaparapara Harbour, and from 0.01 to 1840 sq m in Tryphena Harbour; pou whenua unveiled at three sites.

2022

- #6 NIWA checking on salt treatment sites and shown to be effective; two biosecurity and compliance officers on Island over summer; five ambassadors appointed to help increase public awareness.
- #7 28 January: NIWA check on salt treatment sites showed no caulerpa within treatment sites; additional surveillance carried out at:
 1. Motairehe/Katherine Bay – 6 dives (all negative)
 2. Whangaparapara – 5 dives (just one positive for exotic caulerpa)
 3. Tryphena – 5 dives (all negative)
 4. Port Fitzroy – 8 dives (all negative)
 5. Smokehouse Bay – 2 dives (both negative)
 6. Nagel Cove - 2 dives (both negative).
- #8 11 March: additional surveillance carried out at 12 locations in the Hauraki Gulf.
- #9 30 March: Exotic caulerpa found at Ahuahu between Paritu and Pukekorumiko points as 4 x 0.5 sq m; covered with tarps on 29 March.
- #10 12 April: caulerpa at Ahuahu identified as *C. parvifolia*.
- 20 April: CAN put in place at Ahuahu from Maunganui Point to Ahikopua Point; additional surveillance carried out using new 'star' transect method; hui on Aotea 17 May; exotic caulerpa on Aotea estimated to be 22,700 sq m in Tryphena, 5,300 sq m in Whangaparapara and 880,000 sq m (88 ha) in Okupe (50% of the bay).
- 12 May: NIWA removes mats from salt trials in Tryphena and Whangaparapara; Hui to be held on Aotea 17 May.
- 29 June: CANs extended 3 months until 30 Sept 2022.
- 3 August: additional surveillance carried out north of Whangaparapara in response to reports of caulerpa by community; exotic caulerpa found at (with a negative at Port Fitzroy):
 - Beacon Point (depth of 23 m)
 - French Bay
 - Mangati Bay
 - Walter Hill Bay

- 12 August: The Caulerpa Governance Group recommended CAN be extended from Cape Barrier to Grey Islands at entrance to Port Fitzroy.
- 30 September: CAN extended for 3 weeks with no change.
- 19 October: CAN extended to 31 October; public information campaign started – “see weed chuck it straight back”.
- 25 Oct: anchoring rules tightened; till now anchoring allowed with permits in CAN; fishing allowed from the shore.
- 10 Nov: overview of rules; report of exotic caulerpa by member of the public between Shag Harbour and Schooner Bay; island ambassador and on water compliance check to be rolled out for summer.
- 1 Dec: Pou whenua at Okupe Bay cut down and vandalized; ecological research to get underway early in the New Year.

2023

- 1st Feb: Exotic caulerpa beach cast at Okupe; marker buoys installed to mark edge of CANs; on-water monitoring continues over summer as well as ambassadors on land; messaging from BNZ: “See weed, chuck it straight back. Together, let’s stop the spread. Leave exotic caulerpa where it is.”
- 15th March: NIWA in-water research on impact of exotic caulerpa on native flora and fauna gets underway; Motairehe Ltd get contract to remove exotic caulerpa from Okupe Beach.
- 27th April: CANs extended 6 months until 31 October 2023; NIWA report 90% of the seafloor at Blind Bay covered with exotic caulerpa up to 10 m deep.
- 2nd Aug: exotic caulerpa detected at Waiheke; report from suction dredge TAG released with recommendations to trial this method at two sites; new surveillance by NIWA finds exotic caulerpa through the Broken Islands; NIWA interim research report released; exotic caulerpa web page refreshed.
- 29 September: overview of Aotea suction dredge trial in Tryphena Harbour; 17 tonnes removed and Bay Underwater services able to clear up to 60 sq m per hour; following the dredging parts of the plots (~100 sq m) were covered with benthic mats and chlorine pellets inserted underneath; estimate there is 820 ha of exotic caulerpa-covered seabed (around 800 rugby fields). Trial cleared just on-tenth of a hectare; two sites in Port Fitzroy dredged; hand removal by NIWA divers at Kawau discontinued as progress too slow – 0.1 of a hectare in two weeks with caulerpa across 18 hectares; Strategic TAG set up – expect a report from the TAG in the coming month.
- 30 Nov: updated fishing and anchoring controls at Aotea come in to force 1 December with new CAN which is in force until 30 June 2024; new messaging from BNZ: “Out on the water? See weed? Bag it. Bin it.”; summer campaign to help stop the spread launched.

2024

- 26th February: announcement of \$5 m funding boost to fast-track the development of removal methods; update from Hannah – ambassador Aotea Great Barrier.

Appendix 2

Timeline of key events and media reports on exotic caulerpa from July 2021 to present.
Compiled by Barry Scott (AGBET)



CAULERPA - TIMELINE OF EVENTS	
June 2021	Caulerpa identified by Jack Warden in Okupu/Blind Bay, Aotea Great Barrier: iNaturalist .
September 2021	Controlled Area Notice (CAN) imposed by Biosecurity NZ on Blind Bay and Tryphena harbour (20 September) and later extended to Whangaparapara Harbour.
	Rāhui imposed over three harbours by Mana Whenua.
	'Killer algae' by Kate Evans for New Zealand Geographic (Issue 177 Sep/Oct 2022).
December 2021	Caulerpa detected in Western Bays of Aotea Great Barrier. Aotea Great Barrier Environmental News article by Barry Scott (Issue 45 Summer 2022).
	<p>Note: <i>Caulerpa prolifera</i> detected in Newport Bay, CA in March 2021. Efforts to remove this highly invasive seaweed swung into action within 17 days using a <i>Rapid Response Eradication Plan</i>. While close to 100% has been removed ongoing surveillance is continuing.</p> <p>Earlier detection (2000) of the close relative <i>C. taxifolia</i> in two Southern Californian lagoons (Agua Hedionda Lagoon near San Diego and Huntington Harbor) resulted in successful eradications after a period of 6 years (2006) at a cost of US\$7m.</p>
February 2022	<p>Caulerpa Great Barrier Island 2021 Response, Technical Advisory Group Report. Not publicly available but available on request through OIA request with author names redacted!</p> <p>Note: No mention of diver directed suction dredging as an option for efficient and effective removal of Caulerpa biomass.</p>
August 2022	Hauraki Gulf Forum public meeting with Biosecurity New Zealand to raise alarm about threat of Caulerpa to the Gulf.
	Hauraki Gulf Forum follow up letter to John Walsh, Biosecurity NZ, drawing attention to key provisions in the Hauraki Gulf Management Park Act relevant to the incursion.



CAULERPA - TIMELINE OF EVENTS

November 2022	Waiheke Marine Project set up a marine monitoring and surveillance to detect exotic Caulerpa around Waiheke using two remote operating vehicles (ROV). This project has provided key insights into the immaturity of our marine biosecurity system in NZ.
February 2023	Cyclone Gabrielle hits Great Barrier Island and washes up 50-100 tonne of Caulerpa onto Okupu beach (12-14 February). Motairehe Ltd. Contracted by MPI to clean it up.
March 2023	Susan Botting Stuff interview with Glenn Edney ' Superspreader seaweed threatens Northland coast, ocean ecologist warns ' (16 March).
April 2023	Craig Thorburn, Waiheke Marine Project, presentation <i>Clearing up Caulerpa</i> at Waiheke Festival (23 April). NIWA Caulerpa Report: Impact of Exotic Caulerpa on native species .
May 2023	Te Rawhiti environmental restoration and pest control specialist Rana Rewha (Ngāti Kuta) finds 10-20 cm clumps of Caulerpa on the beach at Omakiwi cove (3 May). Northland Council (Jack Crow) slams Government for lack of action on invasive marine pest (8 May). Revive our Gulf letter to Hon. Damien O'Connor (Minister for Biosecurity) and Hon. Willow-Jean Prime (Minister for Conservation) re 'Exotic Caulerpa: response to this new threat to Tīkapa Moana/Te Moananui-ā-Toi/The Hauraki Gulf (15 May). Northland Regional Council demands urgent meeting with Biosecurity Minister over Caulerpa invader (17 May). Chairs of NRNWKA Trust and Ngāti Paoa Iwi Trust letter to Hon. Damien O'Connor (Minister for Biosecurity) regarding 'Urgent action and budget required to eliminate Caulerpa' (18 May). LegaSea letter to Hon. Damien O'Connor (Minister for Biosecurity), Hon. Willow-Jean Prime (Minister for Conservation) and Hon. Rachel Brooking (Minister for Oceans and Fisheries) re 'Response to exotic Caulerpa in the Hauraki Gulf/Tīkapa Moana' (19 May).



CAULERPA - TIMELINE OF EVENTS

	Spread of Caulerpa to Bay of Islands announced. Susan Botting Stuff ' Caulerpa invader seaweed found in Bay of Islands, Northland ' (19 May).
	Andrea Vance Stuff article Killer seaweed invasion is ' an environmental disaster on the scale of the Rena ' (21 May).
	Aotea Caulerpa Governance Group meeting Monday 22 May – changes to mana whenua membership.
	Mark Leishman RNZ follow up interview with Barry Scott (22 May).
	Bay of Islands shudders as Caulerpa identified in more than a dozen locations . RNZ (30 May).
	Susan Botting Stuff ' Superspreader seaweed found in more than 10 spots in Northland's Bay of Islands ' (30 May).
	Hui at Rawhiti marae for Biosecurity NZ to present to community on presence of Caulerpa in Bay of Islands (31 May).
	Exotic Caulerpa reported to be widespread in Omakiwi Bay, Rawhiti, Bay of Islands (TV3 News 31 May).
June 2023	Anchor ban at Omakiwi Bay (4 June).
	Rapid Response and Eradication of Caulerpa in California: Lessons Learned . Webinar by marine biologist Rachel Woodfield as part of the 2023 California Invasive Species Action Week Lunchtime Talks (5 June).
	North Island Councils combine in urgent call to government for Caulerpa support (8 June).
	CAN put in place in Omakiwi Bay to control the " the maggot of the sea " to quote Kaumatua Hone Martin (12 June).
	CAN a ' step in the right direction ' says Jack Crow (14 June).
	Northland east coast iwi Ngātiwai fear Caulerpa already in rohe (15 June).
	Caulerpa in Northland: fisherman calls for community support (16 June).
	Northland calling for eradication of Caulerpa (21 June).



CAULERPA - TIMELINE OF EVENTS

	AGBET website on Caulerpa set up (25 June).
July 2023	Video of Caulerpa in Schooner Bay by Gray Lewis (4 July).
	Tackling the invasive seaweed Caulerpa in Northland . Kathryn Ryan interviews John Walsh from MPI and Kaeden Leonard from NRC (5 July).
	Caulerpa found in the North Channel northwest of Kawau (7 July).
	Biosecurity NZ disappointed over Caulerpa seaweed find in Hauraki Gulf (8 July).
	“2023 Exotic Caulerpa Suction Dredge Technical Advisory Group Report” completed for Biosecurity New Zealand (10 July).
	Waatea News Interview with Nicola MacDonald/Ngāti Manuhiri Settlement Trust Chief Executive on Caulerpa (13 July).
	Report from Suction Dredge TAG publicly released (22 July).
	MPI Hui on Aotea Great Barrier Island announcing site of Suction Dredge Trial and update on latest surveillance data (25 July).
	John Sibley from Tiritiri Matangi on Caulerpa with very unlikely scenario of Caulerpa arriving here on ocean currents .
August 2023	Caulerpa found at Waiheke (2 August).
	Te Wero Nui “Combating Caulerpa” roadshows at Waitangi, Tāmaki Makaurau and Whitianga (2 August).
	Roadshow to help stop the spread of Caulerpa . Nicola MacDonald talks to Jesse Mulligan on RNZ (2 August).
	Ngāti Rehua Ngātiwai ki Aotea file Waitangi Tribunal claim against the Crown for negligence on allowing Caulerpa to spread at Aotea (4 August).
	Caulerpa invasive seaweed threat spreading , by Susan Bottling (8 August).
	Monumental failure in marine surveillance and biosecurity preparedness – Barry Scott’s editorial in the winter Environmental News (16 August).



CAULERPA - TIMELINE OF EVENTS

	<p>Coromandel marine pest Caulerpa needs more than monitoring, expert says. Commentary by Eric Munoz, consultant and author of the book <i>Caulerpa Conquest</i> (16 August).</p>
	<p>Iwi jumps in to remove invasive seaweed Caulerpa near Kawau Island (18 August).</p>
	<p>Iwi want swift action on seaweed threat – Waatea news (21 August).</p>
	<p>Link for the Caulerpa Surveys by Waiheke Marine Project.</p>
	<p>Super-spreader seaweed Caulerpa to be dredged in Northland’s Bay of Islands (29 August).</p>
	<p>Kate Hawkesby on NewstalkZB – Everyone seems to know what to do about the killer seaweed – Except the Government (30 August).</p>
	<p>Marine Biosecurity News with good information on Caulerpa for boaties and tools for proactive surveillance by Northland Regional Council.</p>
September 2023	<p>MPI to start suction dredge trial in Tryphena (14 September).</p>
	<p>Science Media Centre expert reaction to the MPI media release (14 September).</p>
	<p>Suction Dredge Trail to start soon at Te Rawhiti (15 September).</p>
	<p>Diver directed suction dredge trial carried out at Tryphena Harbour (18-28th Sept). Area of 1200 m² dredged in Shoal, Pūriri and Schooner Bays and mats plus chlorine trialed. Also dredged two sites in Port Fitzroy (FITZ151 and BRO144).</p>
	<p>Off the beaten track with Kennedy Warne on <i>Nine to Noon</i> with Kathryn Ryan (18 September).</p>
	<p>Link to subscribe to Caulerpa Newsletters from MPI.</p>
	<p>Biosecurity New Zealand announces the establishment of a TAG to advise on what management of exotic Caulerpa should look like in the long-term future and a national strategy to achieve this. “Strategic TAG” established to make recommendations on how to manage exotic Caulerpa now that eradication is deemed “not possible” by BNZ (29 September).</p>



CAULERPA - TIMELINE OF EVENTS

October 2023	<p>Kaumatua and community hui at Okiwi agrees to support surveillance proposal to understand how far exotic Caulerpa has spread north to inform Aotea's response and changes to the CAN (29 September).</p>
	<p>Green Party Oceans Policy launches, including a commitment to stop the spread of exotic Caulerpa and increase investment in marine biosecurity (30 September).</p>
	<p>Ngāti Paoa granted permission to remove exotic Caulerpa at Waiheke under section 52 of the Biosecurity Act 1993 (9 October).</p>
	<p>Second MPI Aotea exotic Caulerpa "action group" workshop agrees to progress and jointly fund the surveillance proposal (11 October).</p>
	<p>Help stop the spread of exotic Caulerpa in Tāmaki Makaurau (24 October).</p>
	<p>Original CAN expiry date; MPI extends CAN until 30th November (31 October).</p>
November 2023	<p>Why Northland's Caulerpa invasion is a problem, Susan Bottling (18 November).</p>
	<p>Fears invasive seaweed could cause environmental disaster (19 November).</p>
	<p>Concerns for exotic seaweed on Aotea Great Barrier Island. Charlotte Cook interviews Barry Scott (20 November).</p>
	<p>Green menace: Public meetings held on invasive seaweed Caulerpa. Checkpoint with Lisa Owen, story by Peter de Graaf RNZ (20 November).</p>
	<p>Caulerpa's spread has some Aotea Great Barrier locals throwing in the towel (20 November).</p>
	<p>Sharon Brett Kelly on the Detail: "The smothering weed spreading fast and far" – Interviews with Opo Ngawaka, Barry Scott and MPI (23 November).</p>
	<p>The fast-growing invasive seaweed choking New Zealand's coastline. Eva Corlett for The Guardian (23 November).</p>
	<p>Biosecurity New Zealand hui at Claris. Presentation by John Walsh followed by discussion on the future CAN and next steps for Aotea (23 November).</p>



CAULERPA - TIMELINE OF EVENTS

	<p>First pilot surveillance of Port Fitzroy (funded by AGBET) by Waiheke-based Logan Marine finds no significant Caulerpa but 5 small sites which need further checks. Information was sent to MPI for identification (no response at time of writing – 9 weeks) (21-23 November).</p>
	<p>Waiheke story in Gulf News by Lisa Hamilton (27 November).</p>
	<p>Briefing to Incoming Ministers on Caulerpa from the perspective of affected communities was sent to the new Minister of Biosecurity and 3 others, as well as the offices of the PM and Deputy. Only the Minister for Conservation responds (28 November).</p>
	<p>Biosecurity New Zealand Newsletter (30 November). Updated fishing and anchoring controls at Aotea in force tomorrow. Small piece of exotic Caulerpa found at Medlands Beach. New summer ad campaign to help stop the spread of exotic Caulerpa.</p>
December 2023	<p>Second Logan Marine survey of Port Abercrombie and Port Fitzroy finds no significant exotic Caulerpa but some areas require expert identification (1-3 December).</p>
	<p>MPI and Auckland Council plan media and signage to raise awareness of restrictions in response to please from Aotea community for more support (mid-December).</p>
	<p>Newsroom: Matthew Scott – NZ's most unwanted species invading Hauraki Gulf (12 December).</p>
	<p>Newshub report from Isobel Ewing for TV3 news: Great Barrier Island locals call for urgent action to battle invasive seaweed Caulerpa (17 December).</p>
	<p>Aotea-specific “Help Stop the Spread” flyer and posters are released on-island and in digital media as part of a campaign to raise awareness of restrictions amongst boaties; also used by on-water and wharf ambassadors (MPI refuse to endorse this) (18 December).</p>
	<p>Retrospective eDNA analysis by Michael Bunce, DOC Chief Science Advisor, identified <i>Caulerpa brachypus</i> in samples from Okupe Bay taken in November 2020 – 8 months before first identified by Jack Warden (21 December).</p>



CAULERPA - TIMELINE OF EVENTS

	<p>How to stop superspreading seaweed Caulerpa that can grow 3cm a day, Jamie Morton (26 December).</p>
	<p>Peak boat traffic period: three on-water ambassador boats, and two wharf-based ambassadors, are employed by Auckland Council to educate boaties on stopping the spread of exotic Caulerpa over the summer period (28 December to 29 January).</p>
January 2024	<p>Caulerpa discovered at a new site in Port Abercrombie by a recreational diver. Posted on iNaturalist (7 January).</p>
	<p>More Caulerpa seaweed discovered off Great Barrier Island, locals worried. Jamie Norton for the Herald (16 January).</p>
	<p>Fears invasive seaweed could spread through Hauraki Gulf (17 January).</p>
	<p>Ahu Moana hui; team members note the increase in exotic Caulerpa at Schooner Bay (23 January).</p>
	<p>Craig Thorburn reports that on Waiheke <i>Caulerpa parvifolia</i> has not grown as expected and suggests that given Kawau and Great Mercury have only <i>C. parvifolia</i> it may not be thriving there as well (24 January).</p>
	<p>New Zealand-first dredging machine tackles invasive Caulerpa in Bay of Islands (25 January).</p>
	<p>Ngāti Rehua Ngātiwai ki Aotea Trust agree to progress locally led response (28 January).</p>
	<p>Waiheke Marine Project announces that removal trial of exotic Caulerpa begins at Waiheke Island (31 January).</p>
February 2024	<p>Envirokiwi hand collect samples of <i>Caulerpa brachypus</i> as part of a University of Auckland research project to assess how caulerpa growth is affected by temperature and light (5 February).</p>
	<p>Dale Husbands interviews Barry Scott on Caulerpa (8 February).</p>
	<p>Auckland iwi and carpet company work to eradicate invasive seaweed (11 February).</p>
	<p>Illegal anchoring in Bay of Islands (12 February).</p>



Aotea Great Barrier
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CAULERPA - TIMELINE OF EVENTS

Our Auckland: [Caulerpa update shows active response](#) (14 February).

Our Auckland: Environmental Services: [Aotea Exotic Caulerpa Update](#) (14 February).

[Anchoring breaches within the CAN on Great Barrier Island](#) (17 February).

Government boost to fight against Caulerpa – Hon. Andrew Hoggard. [Media release from the Beehive](#) (23 February).

[Invasive Caulerpa described as biggest threat to New Zealand marine life](#) (10 March).

www.gbiet.org

PO Box 20, Claris, Great Barrier Island, 0961

Phone. 021 082 72377

Facebook. Great Barrier Island Environmental Trust

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Appendices 3-6

Situation reports 5, 6, 7 & 8 on surveillance carried out by NIWA in July 2023 at Aotea.

Situation Report: Aotea and Ahuahu Island exotic Caulerpa Delimitation (MPI Response Panel Contract)

Co-ordinated by:	NIWA																												
Report Number	#005																												
Date and time	23 July 2023																												
Period covered	22 July 07:00-19:00																												
Summary of day's activities	<ul style="list-style-type: none"> - 700-0730 Breakfast at Mercury Cove, trialled Boxfish ROV again and captured limited footage, toolbox meeting and clean anchor prior to transit to Aotea/Great Barrier Island (Figure 1). - 0745- 1000 Transit from Mercury Cove to Tryphena Harbour to meet Jeff Cleave from Ngati Rehua. - 1000-1100 Karakia at Tryphena harbour, attempted to use the Boxfish to dive the deepwater fishing sites off Schooner Bay (ROV134, 135 and 136, Figure 2) but the weather made sea conditions too rough. When trialling the third site ROV deployment it stopped working. - 1100-1200 transit to Bowling Alley Bay to get protection from the wind and swell. - 1200-1250 Two fifteen-minute dive transect searches in Bowling Alley Bay, extensive exotic Caulerpa found, and decision made to search further north rather than within the Bay (BOW142, BOW147) Exotic Caulerpa found at both sites (Table 1, Figure 2). - 1300-1415 Two fifteen-minute dive transect searches in the Southern Broken Islands (BRO138-139), extensive exotic Caulerpa was found and decision made to return to the ROV transects on the way to dropping Jeff back off to Tryphena. Exotic Caulerpa found at both sites (Table 1, Figure 2). - 1430-1515 Transit from the Broken Islands Back to the ROV sites north of Tryphena Harbour. - 1520-1600 Two fifteen-minute dive transect searches at the ROV sites near Schooner Bay (ROV137-138). Exotic Caulerpa found at both sites (Table 1, Figure 2). - 1600-1730 Dropped Jeff back to Tryphena Harbour and returned north to the Broken Islands to anchor for the night. <p style="text-align: center;">Table 1: Summary of exotic Caulerpa findings</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Site</th> <th>X</th> <th>Y</th> <th>Caulerpa found</th> </tr> </thead> <tbody> <tr> <td>BOW142</td> <td>175.3258644</td> <td>-36.2251366</td> <td>90% cover deeper than 20m and between 10-25% cover shallower areas across the transect</td> </tr> <tr> <td>BOW147</td> <td>175.32241</td> <td>-36.22333643</td> <td>60% cover deeper than 10m and 5-10% cover shallower areas across the rest of the transect</td> </tr> <tr> <td>BRO145</td> <td>175.306807</td> <td>-36.23068361</td> <td>19-11m depth 100% cover, shallower than 11m 70% cover.</td> </tr> <tr> <td>BRO139</td> <td>175.3144517</td> <td>-36.22804687</td> <td>Over 10m 75% cover and 5-10% cover in shallower areas across the rest of the transect</td> </tr> <tr> <td>ROV138</td> <td>175.43154</td> <td>-36.30878981</td> <td>25-50% cover across the transect, with higher density in deeper water.</td> </tr> <tr> <td>ROV137</td> <td>175.4345606</td> <td>-36.311325</td> <td>25-50% cover across the transect, with higher density in deeper water. Vertical walls with sponge gardens covered in Caulerpa</td> </tr> </tbody> </table> <ul style="list-style-type: none"> - 1730-1800 The dive team updated the project manager of the daily activities and sent the data through for SitRep - 1800 to 1900 Complete SitRep and collate data. 	Site	X	Y	Caulerpa found	BOW142	175.3258644	-36.2251366	90% cover deeper than 20m and between 10-25% cover shallower areas across the transect	BOW147	175.32241	-36.22333643	60% cover deeper than 10m and 5-10% cover shallower areas across the rest of the transect	BRO145	175.306807	-36.23068361	19-11m depth 100% cover, shallower than 11m 70% cover.	BRO139	175.3144517	-36.22804687	Over 10m 75% cover and 5-10% cover in shallower areas across the rest of the transect	ROV138	175.43154	-36.30878981	25-50% cover across the transect, with higher density in deeper water.	ROV137	175.4345606	-36.311325	25-50% cover across the transect, with higher density in deeper water. Vertical walls with sponge gardens covered in Caulerpa
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Actions carried out	<ul style="list-style-type: none"> • Transit from Ahuahu to Aotea • Karakia and pick up Ngati Rehua representative • Test dives with Boxfish ROV • 6 dive transects in Aotea • Data collation, mapping and SitRep. 																												
Plan for tomorrow	<ul style="list-style-type: none"> • Complete 10 fifteen-minute dive searches in Broken Islands, Port Fitzroy and Port Abercrombie area 																												

Table 2: Transect locations, substrate, depth and presence of exotic Caulerpa (in yellow) completed during the delimitation survey in July 2023 by NIWA divers

Site ID (i.e. Dive01/Rov 01)	Start Coordinates		End Coordinates		Depth category ¹	Water temp	Max depth	Transect width	Substrate ²	Approx. Visibility (m)	Caulerpa (Y/N)
	Lat	Long	Lat	Long							
BOW142	175.3258644	-36.2251366	175.3243642	-36.22525513	D	15	18.5	8	5	8	Y
BOW147	175.32241	-36.22333643	175.3218931	-36.22184785	D	14	11.5	8	3-9	6	Y
BRO139	175.306807	-36.23068361	175.3062822	-36.22984209	D	15	17.8	8	3-8	10	Y
BRO145	175.3144517	-36.22804687	175.3157784	-36.22675809	D	15	19	8	3-5	10	Y
ROV138	175.43154	-36.30878981	175.4318211	-36.30775007	D	15	14.4	8	8	8	Y
ROV137	175.4345606	-36.311325	175.4356341	-36.31059255	D	15	21	8	8	10	Y

1Depth Category codes (NS <2m, S 2-5m, M, 5-10m, D >10m)
 2Substrate codes: 1- Sandy mud, 2- Muddy sand, 3- Sand, 4- Sandy gravel, 5- Shelly gravel, 6- Sand fowl, 7- Sand reef, 8- Reef, 9- Other (Please state), 10 - Mud can have multiple codes ADD COMMENTS



Figure 1: Anchor chain disinfection and dive gear disinfection post-diving at the infected sites at Aotea.

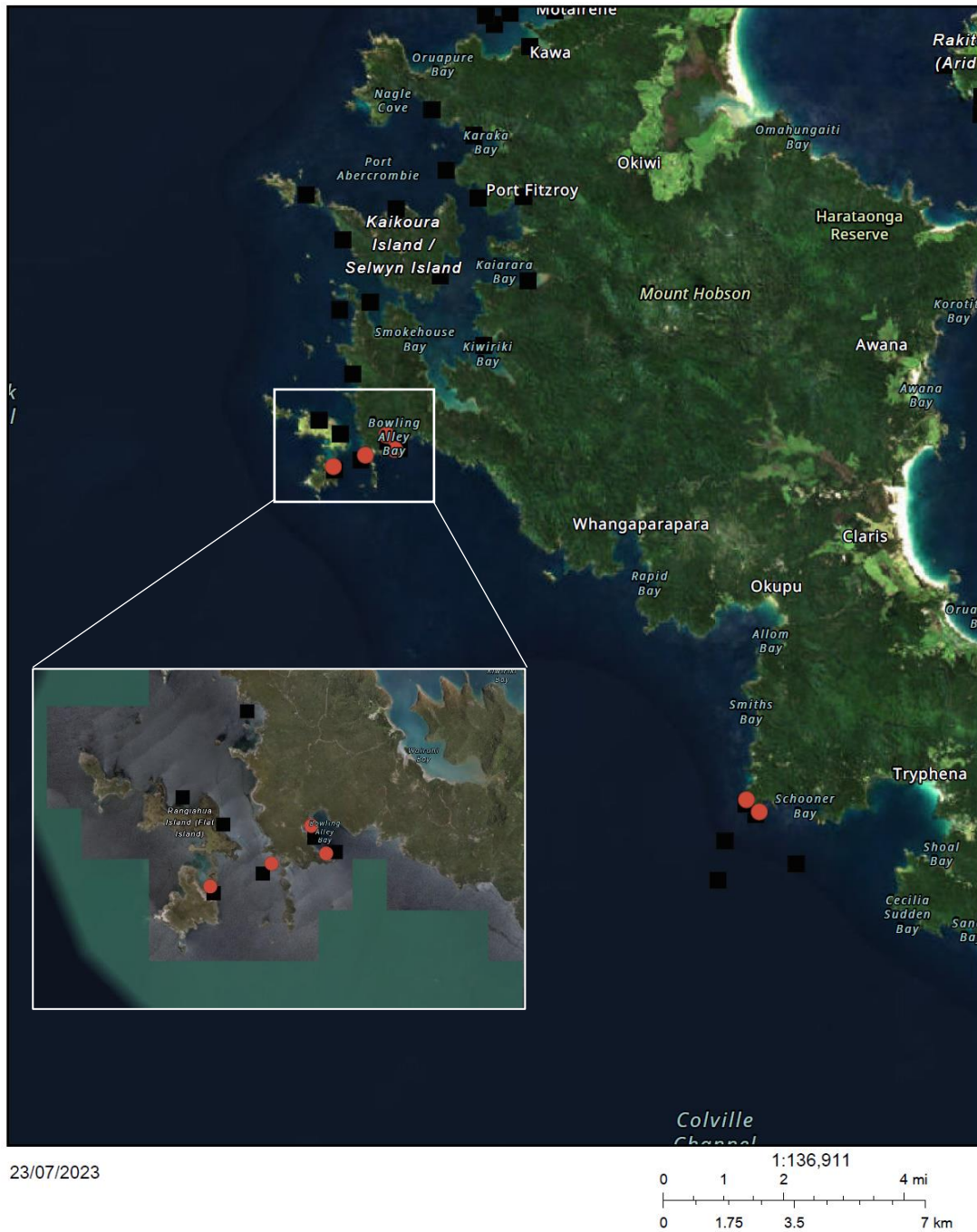


Figure 2: Start points without exotic *Caulerpa* (green circles), start points with exotic *Caulerpa* (red circles), and end (black squares) points for the dive searches completed around Aotea/Great Barrier Island 22 July 2023. Inset depicts close up of the Bowling Alley Bay and Broken Island sites.

Situation Report: Aotea and Ahuahu Island exotic Caulerpa Delimitation (MPI Response Panel Contract)

Co-ordinated by:	NIWA																																
Report Number	#006																																
Date and time	24 July 2023																																
Period covered	23 July 07:00-19:00																																
Summary of day's activities	<ul style="list-style-type: none"> - 0700-0730 Breakfast at Broken Islands toolbox meeting and clean anchor prior to transit to Port Fitzroy (Figure 1). - 0730-1030 Six fifteen-minute dive transects completed from Broken Islands north toward Port Fitzroy (BRO140, 141, 143, 144, 148) to meet Jeff Cleave from Ngati Rehua) Exotic Caulerpa was found at all sites apart from BRO140 (Table 1, Figure 2). - 1030-1140 Pick up Jeff Cleave at Port Fitzroy and refuel and refill freshwater. - 1140-1420 Five fifteen-minute dive transect searches in the Port Fitzroy area (FITZ149- 151, FITZ154-155) Exotic Caulerpa found at FITZ151 (Table 1, Figure 2). - 1445-1630 Three fifteen-minute dive transect searches in the Port Abercrombie area (ABC152, 153, 157, Table 2, Figure 1). No exotic Caulerpa detected. - 1630-1740 Transit back to Port Fitzroy wharf to drop Jeff back and anchor in Port Fitzroy for the night. - 1745-1800 The dive team updated the project manager of the daily activities and sent the data through for SitRep - 1800 to 1900 Complete SitRep and collate data. <p style="text-align: center;">Table 1: Summary of exotic Caulerpa findings</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Site</th> <th style="text-align: left;">X</th> <th style="text-align: left;">Y</th> <th style="text-align: left;">Caulerpa found</th> </tr> </thead> <tbody> <tr> <td>BRO143</td> <td>175.3107595</td> <td>-36.20733423</td> <td>100% cover for the first 10 minutes of the dive, a lot of fragments, density was reduced at 7m. Average overall cover 25-50% across the transect.</td> </tr> <tr> <td>BRO146</td> <td>175.3010451</td> <td>-36.21826111</td> <td>Over 95% cover across the transect.</td> </tr> <tr> <td>BRO140</td> <td>175.3106181</td> <td>-36.19173449</td> <td>6 patches smaller than 5cm, 3 patches between 5-20cm, 12 patches 20-50cm.</td> </tr> <tr> <td>BRO141</td> <td>175.3187729</td> <td>-36.18535238</td> <td>24 patches smaller than 5cm, 10 patches between 5-20cm, 1 patch 75-100cm</td> </tr> <tr> <td>BRO148</td> <td>175.3181316</td> <td>-36.19147288</td> <td>17 patches smaller than 5cm, 6 patches between 5-20cm, 2 patches 20-50cm, 1 patch 50-75cm</td> </tr> <tr> <td>BRO144</td> <td>175.3307227</td> <td>-36.1898289</td> <td>5 patches smaller than 5cm, 3 patches between 5-20cm, 1 patch 50-75cm, 1 patch 150-200cm</td> </tr> <tr> <td>-</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Site	X	Y	Caulerpa found	BRO143	175.3107595	-36.20733423	100% cover for the first 10 minutes of the dive, a lot of fragments, density was reduced at 7m. Average overall cover 25-50% across the transect.	BRO146	175.3010451	-36.21826111	Over 95% cover across the transect.	BRO140	175.3106181	-36.19173449	6 patches smaller than 5cm, 3 patches between 5-20cm, 12 patches 20-50cm.	BRO141	175.3187729	-36.18535238	24 patches smaller than 5cm, 10 patches between 5-20cm, 1 patch 75-100cm	BRO148	175.3181316	-36.19147288	17 patches smaller than 5cm, 6 patches between 5-20cm, 2 patches 20-50cm, 1 patch 50-75cm	BRO144	175.3307227	-36.1898289	5 patches smaller than 5cm, 3 patches between 5-20cm, 1 patch 50-75cm, 1 patch 150-200cm	-			
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Actions carried out	<ul style="list-style-type: none"> • 14 dive transects around the Port Fitzroy area. • Data collation, mapping, and SitRep. 																																
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Site ID (i.e. Dive01/Rov 01)	Start Coordinates		End Coordinates		Depth category ¹	Water temp	Max depth	Transect width	Substrate ²	Approx. Visibility (m)	Caulerpa (Y/N)
	Lat	Long	Lat	Long							
BRO143	175.3107595	-36.20733423	175.3132171	-36.20777932	M	14	9.7	8	7-8	8	Y
BRO146	175.3010451	-36.21826111	175.3028025	-36.21902926	D	14	19	8	3	8	Y
BRO140	175.3106181	-36.19173449	175.311252	-36.1922384	M	14	10	10	3-8	10	N
BRO141	175.3187729	-36.18535238	175.3204313	-36.18653962	D	14	18.9	8	3-8	8	Y
BRO148	175.3181316	-36.19147288	175.3183094	-36.19262216	D	14	14.4	4	2	3	Y
BRO144	175.3307227	-36.1898289	175.3297932	-36.18947275	D	14	14.4	8	3-8	8	Y
FITZ155	175.3608987	-36.16351523	175.3594502	-36.16488234	M	14	12	3	2	1.5	N
FITZ150	175.3595467	-36.18275781	175.3614145	-36.18165331	D	14	15.5	3	10	1.5	N
FITZ149	175.3484357	-36.20084925	175.3488023	-36.19947629	D	14	14.4	3	10-8	4	N
FITZ151	175.3363786	-36.1835511	175.3345745	-36.18236582	D	14	15.3	8	3-5	8	Y
FITZ154	175.336173	-36.1648574	175.3357643	-36.16648053	D	14	15.2	8	3-8	8	N
ABC152	175.3237217	-36.16826485	175.3247303	-36.1693576	D	15	14	8	3-8	8	N
ABC153	175.3015553	-36.16512971	175.3011968	-36.16408413	D	15	17	8	8-3	8	N
ABC157	175.3454585	-36.14849863	175.3472835	-36.14739287	D	15	13.2	5	3-5	6	N

¹Depth Category codes (NS <2m, S 2-5m, M, 5-10m, D >10m)
²Substrate codes: 1- Sandy mud, 2- Muddy sand, 3- Sand, 4- Sandy gravel, 5- Shelly gravel, 6- Sand fowl, 7- Sand reef, 8- Reef, 9- Other (Please state), 10 - Mud can have multiple codes ADD COMMENTS

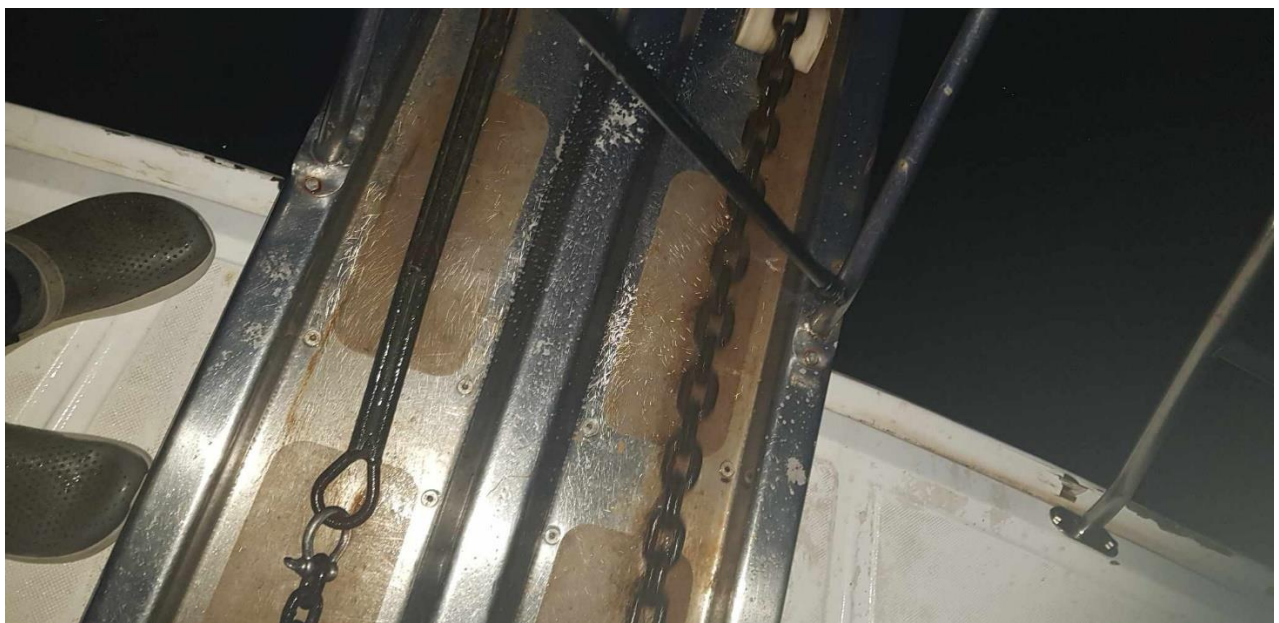
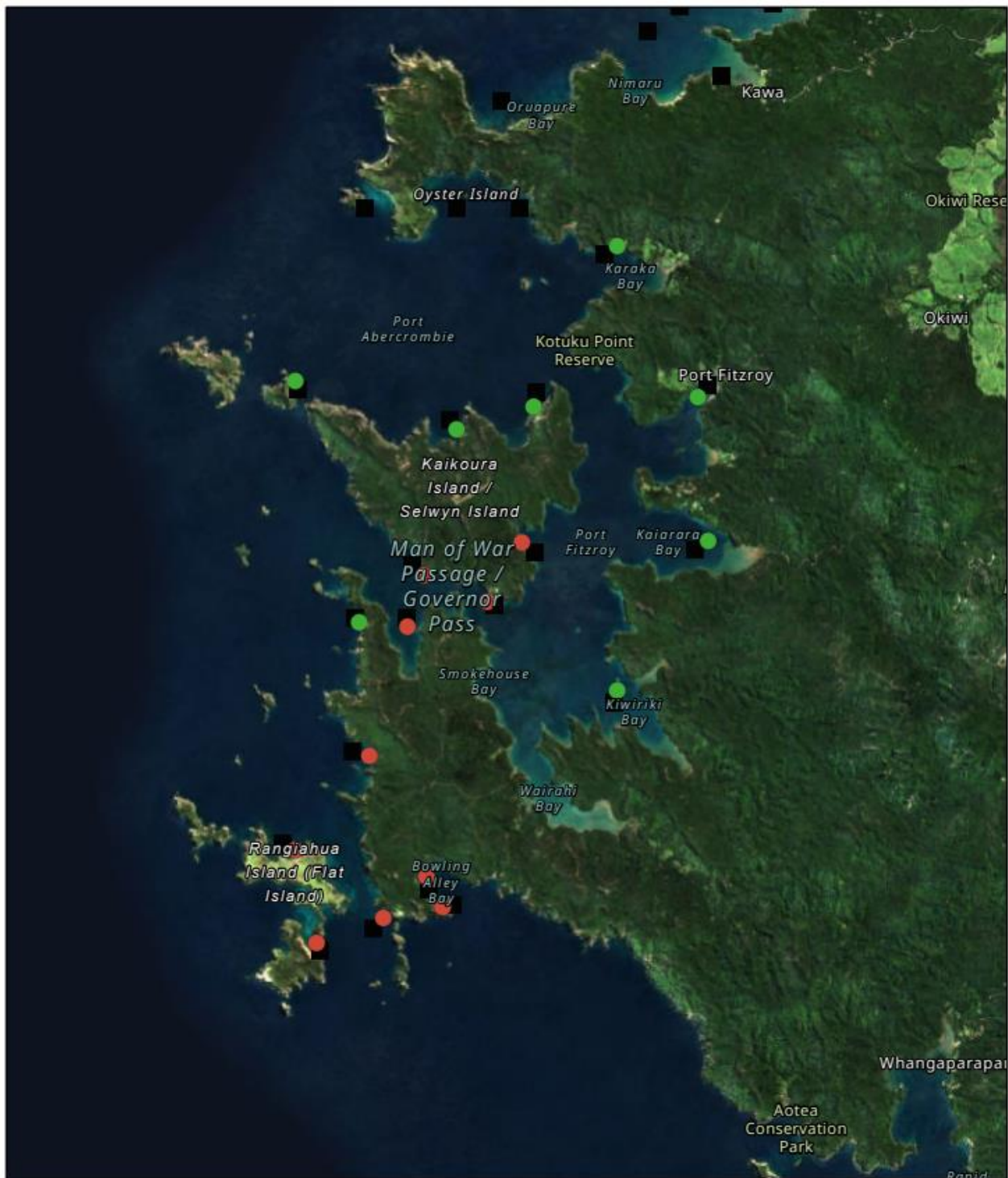


Figure 1: Anchor chain disinfection and dive gear disinfection post-diving at the infected sites at Aotea.



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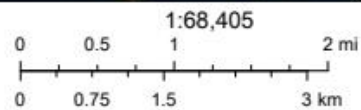


Figure 2: Start points without exotic *Caulerpa* (green circles), start points with exotic *Caulerpa* (red circles), and end (black squares) points for the dive searches completed around Aotea/Great Barrier Island 23 July 2023. Inset depicts close up of the Bowling Alley Bay and Broken Island sites.

Situation Report: Aotea and Ahuahu Island exotic Caulerpa Delimitation (MPI Response Panel Contract)

Co-ordinated by:	NIWA
Report Number	#007
Date and time	24 July 2023
Period covered	24 July 07:00-19:00
Summary of day's activities	<ul style="list-style-type: none"> - 0700-0730 Breakfast at Port Fitzroy, toolbox meeting and clean anchor prior to transit to Port Fitzroy (Figure 1). - 0730-0815 Three fifteen-minute dive transects completed in Port Abercrombie (ABC158, ABC156, MOT172; Figure 1, Table 1). No exotic Caulerpa was detected. - 0820- 0920 Transit from Port Abercrombie to Motairehe/Katherine Bay to pick up Jeff Cleave. - 0945-1410 Nine fifteen-minute dive transect searches in the Port Fitzroy area (MOT164-MOT171; Figure 1, Table 1). No exotic Caulerpa was detected. - 1430-1540 Transit from Motairehe to Rangiwahakaea Bay and Okiwi Bay - 1540-1620 Two fifteen-minute dive transect searches on the Aotea east coast (ARI159-160; Figure 1, Table 1). No exotic Caulerpa was detected. - 1620-1730 Transit to Whangapoua to drop Jeff Cleave off and anchor in a sheltered bay off the coast. - 1745-1800 The dive team updated the project manager of the daily activities and sent the data through for SitRep. - 1800-1900 Complete SitRep and collate data.
Actions carried out	<ul style="list-style-type: none"> • 14 dive transects around Motairehe and Eastern Aotea. • Data collation, mapping, and SitRep.
Plan for tomorrow	<ul style="list-style-type: none"> • Complete 3 fifteen-minute dive searches at Arid island and an additional 3 dives at the edges of the infestation at Port Fitzroy • Disinfect vessel, anchor and gear before transiting to Tutukaka harbour to drop off two of the out-of-town divers to catch flights at Wednesday morning. • The additional Northland staff will stay onboard to unload the vessel at Whangaruru

Table 1: Transect locations, substrate, depth and presence of exotic Caulerpa (in yellow) completed during the delimitation survey on 23 July 2023 by NIWA divers

Site ID (i.e. Dive01/Rov01)	Start Coordinates		End Coordinates		Depth category ¹	Water temp	Max depth	Transect width	Substrate ²	Approx. Visibility (m)	Caulerpa (Y/N)
	Lat	Long	Lat	Long							
ABC156	175.321432	-36.142656	175.3341733	-36.14257163	D	14	15.4	6	7-8	8	N
ABC158	175.3326526	-36.14357965	175.3191869	-36.14207726	D	14	15	8	3	8	N
ARI159	175.4332324	-36.11646188	175.3121004	-36.13726453	D	14	18	8	3-8	8	N
ARI160	175.4106929	-36.0894546	175.3338217	-36.13112317	D	15	12.5	8	3-8	8	N
MOT164	175.3601895	-36.1257584	175.3474682	-36.1257362	D	15	15.2	4	2	4	N
MOT165	175.3492991	-36.12591988	175.3601235	-36.12727709	M	15	5.7	2	3-8	1	N
MOT166	175.3323594	-36.1291381	175.3549964	-36.12049308	D	14	15.7	8	2	8	N
MOT167	175.3555088	-36.11926296	175.3604942	-36.11491369	M	14	10	8	10	8	N
MOT168	175.3497122	-36.11205346	175.350171	-36.11016231	D	14	12.8	8	10-8	8	N
MOT169	175.3590157	-36.11619379	175.3482447	-36.10628495	D	15	18.6	8	3-5	8	N
MOT170	175.3419655	-36.09694891	175.3460786	-36.09906375	D	15	11.5	6	3-8	6	N
MOT171	175.3470071	-36.10569675	175.3425122	-36.09582105	D	15	13.4	6	3-8	6	N
MOT172	175.310486	-36.13708296	175.4104339	-36.09116108	M	14	9.1	3	8-3	1	N
MOT173	175.3453486	-36.10032842	175.432346	-36.11439874	M	14	10	6	3-5	4	N

¹Depth Category codes (NS <2m, S 2-5m, M, 5-10m, D >10m)
²Substrate codes: 1- Sandy mud, 2- Muddy sand, 3- Sand, 4- Sandy gravel, 5- Shelly gravel, 6- Sand fowl, 7- Sand reef, 8- Reef, 9- Other (Please state), 10 - Mud can have multiple codes ADD COMMENTS



Figure 1: Anchor chain disinfection post anchoring in Port Fitzroy for the night.

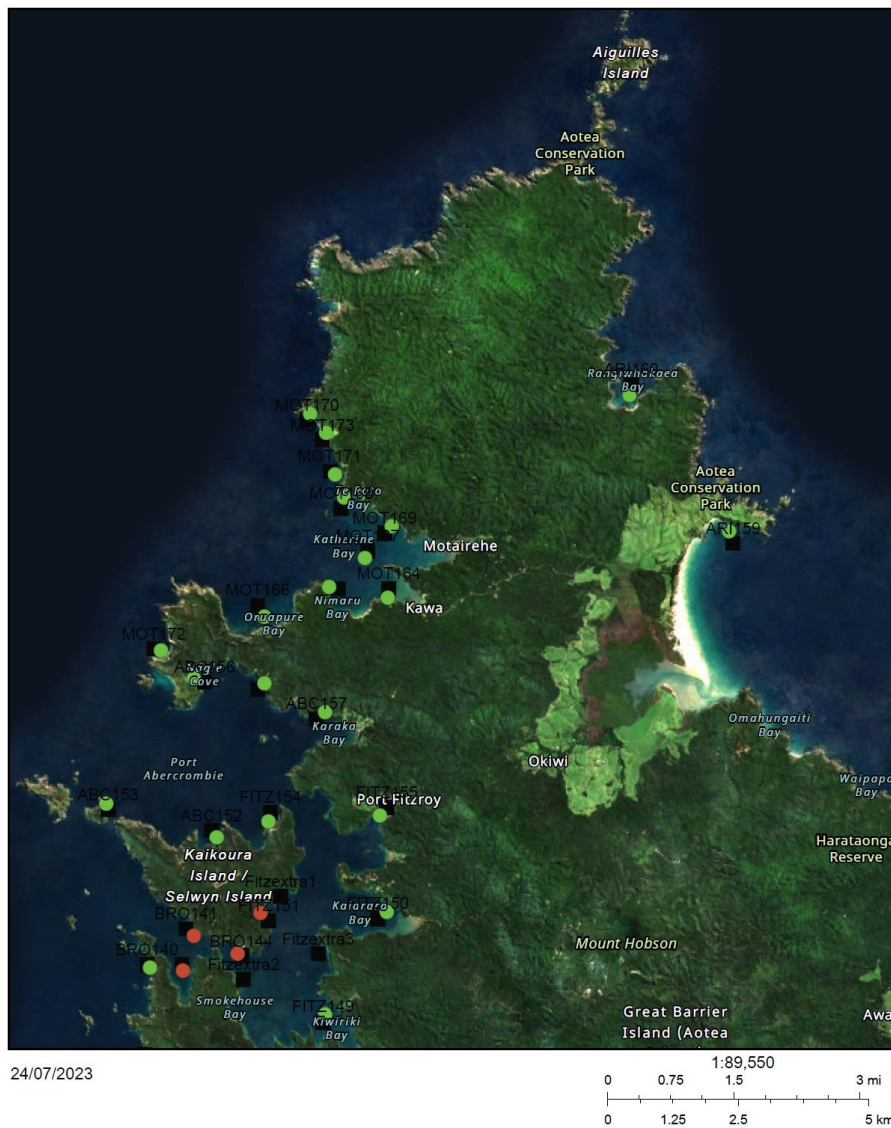


Figure 2: Start points without exotic *Caulerpa* (green circles), start points with exotic *Caulerpa* (red circles), and end (black squares) points for the dive searches completed around Aotea/Great Barrier Island on 23 and 24 July 2023.

Situation Report: Aotea and Ahuahu Island exotic Caulerpa Delimitation (MPI Response Panel Contract)

Co-ordinated by:	NIWA
Report Number	#008
Date and time	25 July 2023
Period covered	25 July 07:00-19:00
Summary of day's activities	<ul style="list-style-type: none"> - 0700-0730 Breakfast at anchorage, toolbox meeting and clean anchor prior to transit to Okiwi to meet Jeff Cleave. - 0730-0845 Three fifteen-minute dive transects completed in The Cove at Arid Island (ARI161-ARI163; Figure 1, Table 1). No exotic Caulerpa was detected. - 0900-1040 Transit from Arid Island to Port Fitzroy. - 1045-1315 Three fifteen-minute dive transect searches in the Port Fitzroy area adjacent to the exotic Caulerpa edges (FITZextra1-3; Figure 1, Table 1). No exotic Caulerpa was detected. - 1330-1400 Disinfect entire vessel and all dive gear using Chlorine and detergent (Figure 2) prior to transit back up to Tutukaka to fuel up and anchor for the night. The dive team updated the project manager of the daily activities and sent the data through for SitRep. The two out of town divers will be dropped off at Tutukaka to fly home on Wednesday morning and the two Northland staff will stay on the vessel to transit to Whangaruru to demobilise equipment on Wednesday evening. - 1400-1730 transit from Port Fitzroy to Tutukaka - 1830-1900 Complete SitRep and collate data.
Actions carried out	<ul style="list-style-type: none"> • 6 dive transects around Port Fitzroy and Arid Island. • Vessel and gear disinfection and transit back to Northland. • Data collation, mapping, and SitRep.
Plan for tomorrow	<ul style="list-style-type: none"> • Disembark two out of town divers to travel back to Wellington and Nelson • Transit to Whangaruru and demobilise equipment

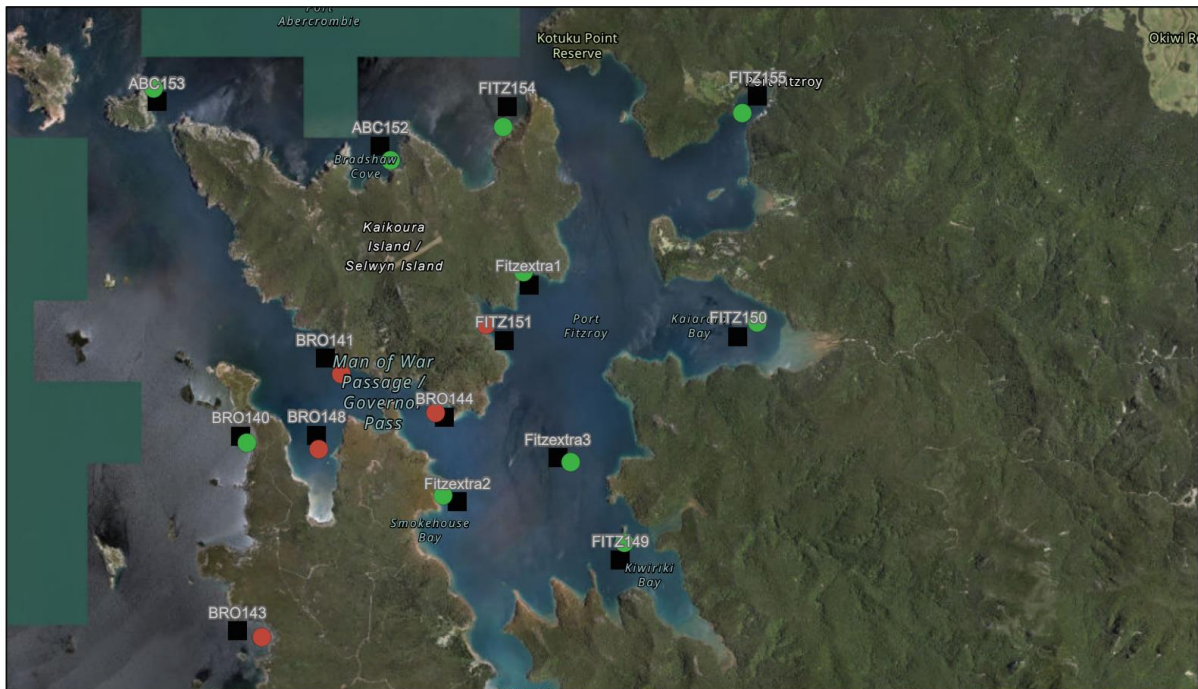
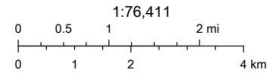
Table 1: Transect locations, substrate, depth and presence of exotic Caulerpa (in yellow) completed during the delimitation survey on 25 July 2023 by NIWA divers

Site ID (i.e. Dive01/Rov01)	Start Coordinates		End Coordinates		Depth category ¹	Water temp	Max depth	Transect width	Substrate ²	Approx. Visibility (m)	Caulerpa (Y/N)
	Lat	Long	Lat	Long							
ARI161	175.49265	-36.11881561	175.4943118	-36.12014622	D	15	13.9	6	8-3	8	N
ARI162	175.4916261	-36.11829342	175.490979	-36.11911825	D	14	14.5	8	8-3	8	N
ARI163	175.4937996	-36.1205718	175.4919381	-36.11850946	D	15	14.7	8	3-8	8	N
Fitzextra1	175.3387185	-36.17903761	175.3382143	-36.17808145	D	14	17	8	3-5	8	N
Fitzextra2	175.3321931	-36.19654783	175.3307159	-36.19610442	D	14	16	4	3-5	5	N
Fitzextra3	175.3419992	-36.19288292	175.3432952	-36.19315445	D	14	19	2	8-9	6	N

¹Depth Category codes (NS <2m, S 2-5m, M, 5-10m, D >10m)
²Substrate codes: 1- Sandy mud, 2- Muddy sand, 3- Sand, 4- Sandy gravel, 5- Shelly gravel, 6- Sand fowl, 7- Sand reef, 8- Reef, 9- Other (Please state), 10 - Mud can have multiple codes ADD COMMENTS



25/07/2023



25/07/2023

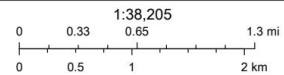


Figure 1: Start points without exotic *Caulerpa* (green circles), start points with exotic *Caulerpa* (red circles), and end (black squares) points for the dive searches completed around Aotea/Great Barrier Island in July 2023. Arid Island and east coast sites in upper map and Port Fitzroy in lower map.

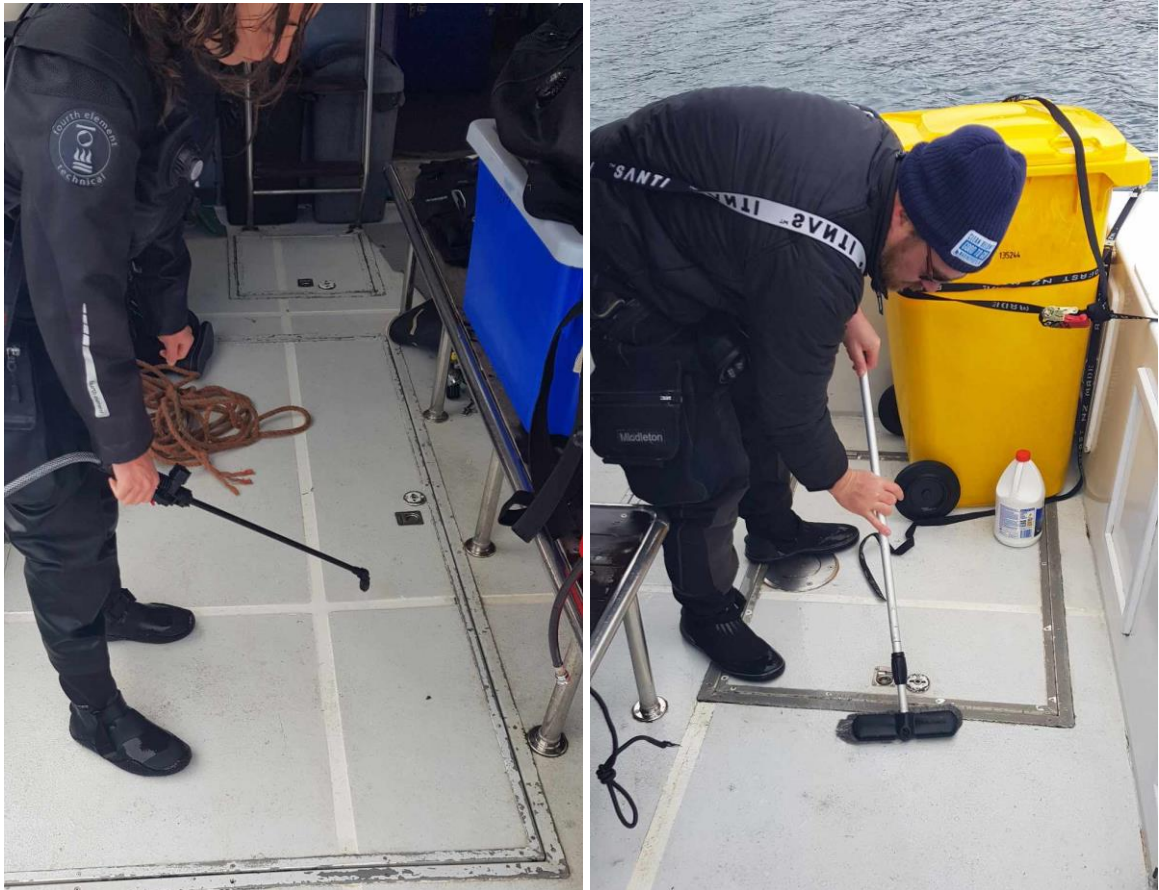


Figure 2: Chlorine spray and wash down of the vessel prior to leaving Aotea Island.