

Aerial macroalgae mapping

Catlins Estuary, Otago

Prepared for Otago Regional Council

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1 Introduction

1.1 Background

Agarophyton spp (previously *Gracilaria*) is a filamentous red macroalgae that can form extensive beds within estuaries and harbours and along sheltered coastlines. Dense mats are commonly associated with high nutrient loads and have been found across Aotearoa. Its ability to colonise new areas is facilitated by fragmented thalli being readily transported by wind, waves and currents, and then rapid growth occurring when substrate settlement allows (Nelson et al. 2015). Once established, multiple characteristics enable *Agarophyton* spp to persist, including high nutrient uptake capacity, the ability to grow under limited light conditions and having a wide salinity and desiccation tolerance (Pedersen and Borum 1996; Carnicas et al. 1999; Nyberg 2007). Over time, this can come at a detriment to healthy ecosystem functioning as large beds can outcompete perennial macrophytes such as seagrasses.

Dense beds of *Agarophyton* spp can also have negative societal effects as a result of increased odour and fouling of local beaches, fishing lines and nets. They are therefore often considered a nuisance species by local communities. Problems associated with blooms of this species have been highlighted in eutrophic estuaries such as New River Estuary, Southland and Ihutai (Avon-Heathcote) Estuary in Canterbury (Dudley et al. 2022).

Increasing growth of *Agarophyton* spp has been identified by Otago Regional Council (ORC) in southern estuaries, including the Catlins Estuary. While these beds can be mapped by field teams, more efficient methods, such as aerial imaging provide an efficient alternative to manual delimitation of bed size, and may enable the detection of otherwise inaccessible beds. However, cross-calibration of biomass measurements by field teams with aerial images has the potential to further improve the utility of aerial imaging products.

1.2 Our understanding of your requirements

It is our understanding that ORC requires a suitable qualified provider of aerial imaging services, particularly multispectral imagery, to better relate algal spectral signatures to estimates of biomass. We understand that manual delimitation of the beds has recently occurred, and that high resolution aerial imagery will leverage this information to assess the utility of aerial methods to be used more widely. These services are required within the upper Catlins Estuary.

1.3 Scope of the project

NIWA will perform an aerial imaging field campaign using multispectral cameras of the upper section of intertidal mudflat within the Caltins Estuary (Figure 1-1). NIWA will simultaneously perform high resolution validation of aerial imagery coordinates (using ground control points), sample *Agarophyton spp* positions, and take a small number of geo-located biomass samples. Combined, this will provide spatially validated aerial imagery, production of classified habitat maps, and estimates of classification accuracy over the full extent of Catlins Estuary.

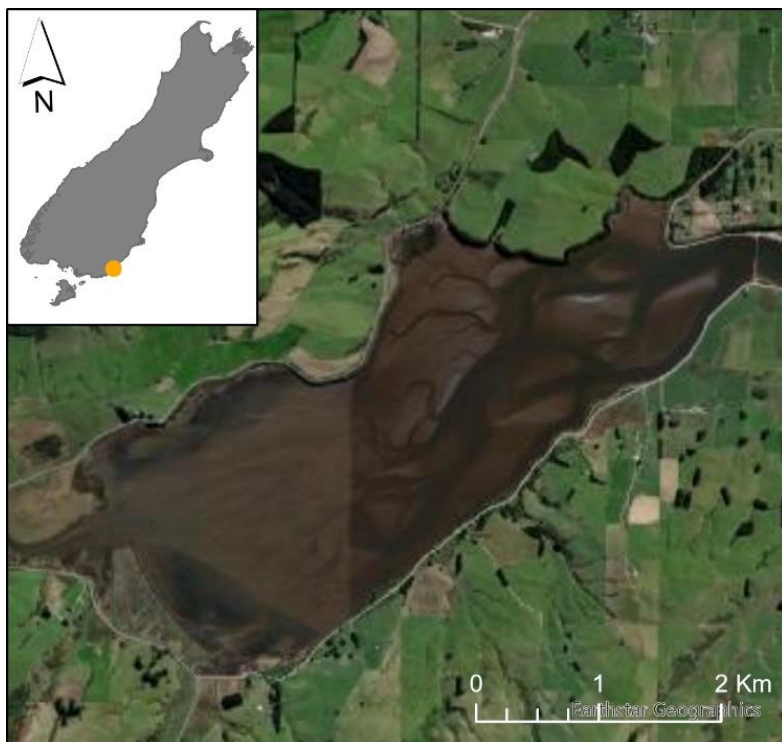


Figure 1-1: An aerial image of the survey area within the upper Catlins Estuary and its location on the South Island of New Zealand.

1.4 Purpose

This proposal is provided solely for the purpose of demonstrating to you NIWA's ability to provide the services and for no other purpose. The proposal may not be used by or distributed to a third party for any other purpose without NIWA's prior written consent.

2 Methods

Agarophyton spp beds commonly occur within sheltered intertidal mudflats. Whilst habitat extent can be mapped manually, these methods are often labour intensive and can be restricted to only the accessible areas of intertidal flats. Aerial drones allow potentially inaccessible habitat to be captured and can map *Agarophyton spp* beds efficiently over moderate scales. We will map the intertidal area of the upper Catlins Estuary. This imagery will be used to create maps that will provide detail on the extent of *Agarophyton spp* beds within this estuary and will provide a comparison to the manual delimitation of bed extent which has already been completed.

We will capture multispectral imagery from Unmanned Aerial Vehicle (UAV) platforms. We will use these data to separate *Agarophyton spp* from non-biological substrata, invertebrate assemblages

and other macroalgae. We will use a DJI M200 UAV and Micasense Dual multispectral camera system. To geo-reference the RGB and multispectral imagery, ground control targets will be laid out across the Region of Interest (ROI). Each target will be surveyed using a high accuracy Real-Time Kinetic Global Positioning System (RTK-GPS; Trimble Inc., Sunnyvale, California, United States). Furthermore, we will survey between 200–400 rapid “validation points”, and 30-50 biomass samples using the same RTK-GPS equipment. These *in situ* point surveys allow the collection of large numbers of rapid samples of various habitat types. The resulting dataset will provide the foundation for accuracy assessments of habitat classification and help generate relationships between remotely detected spectral signatures and *in situ* biomass. An example of the outputs from aerial imagery is shown in Figure 2-1.

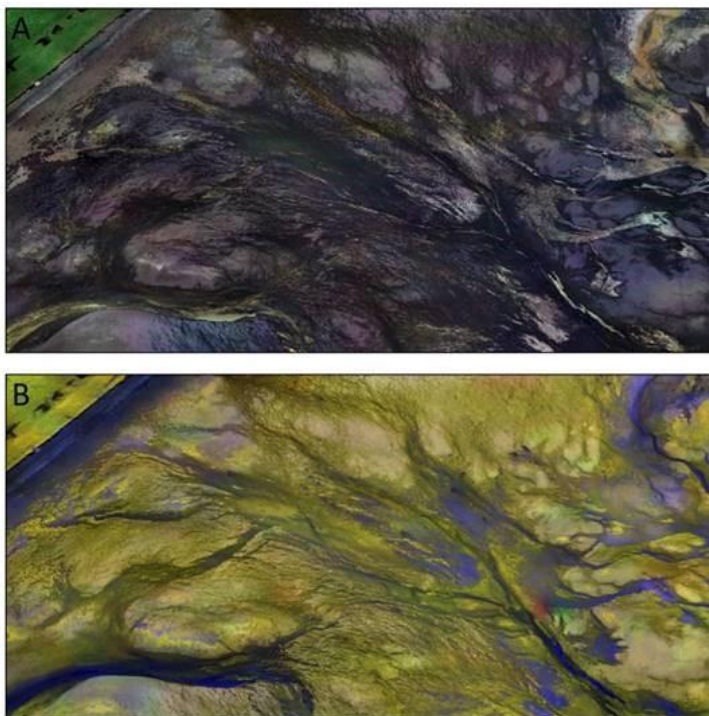


Figure 2-1: Agarophyton beds in Humphries basin observed in real colour (A) and false colour images (B). Real colour imagery shows light from red, green, and blue wavelengths (665, 560, and 475 nm) and the false colour imagery shows light from near-infrared, red-edge and blue wavelengths (830, 740, and 475 nm). The false colours image enhances the visibility of photosynthetic material.

The purpose of data collection is to provide estimates from aerial imagery of the extent of *Agarophyton* spp beds within the upper Catlins Estuary. These data will be collected during a one-off survey.

2.1 Next steps

Following imagery capture we will then stitch the imagery dataset together into large “orthomosaic” images. These images will then be classified using machine learning techniques, and the accuracy of these classifications will be compared to validation datasets completed with high resolution GPS systems (Tait. et al. 2019; 2021). We will use these classifications to calculate the coverage of *Agarophyton* spp and other dominant aquatic vegetation species. Furthermore, we will examine the potential to generate remote biomass estimates using geo-located biomass samples.

We will provide these data in a short-form report.

2.2 Our understanding of your contributions to the project

We understand that Salt Ecology Ltd have recently completed manual surveys of Catlins Estuary and that these data may be made available for a cross-study assessment of the full extent of *Agarophyton* spp beds. It is our understanding that this comparison is not a direct output of the proposed research, however, direct comparisons may be possible given that these data are provided in a timely manner and in an appropriate format.

3 What we will deliver

3.1 Outputs

A report summarising the outputs of the project described above will be submitted to Otago Regional Council by 31 August 2022. The report will include a description of the methods used during the collection of drone aerial images, as well as imagery analyses. The results of these analyses will include examples of the imagery obtained within this project and estimated *Agarophyton* spp bed extent within the upper Catlins Estuary.

The report and data will provide sufficient information so that comparisons can be made to the manual mapping of *Agarophyton* spp beds which was completed earlier this year.

Unless otherwise agreed NIWA will provide reports in the style of its standard client report.

Otago Regional Council will be provided with (for example):

- Digital copies of the report in Word and PDF format.
- Electronic data files (e.g., TIFF images, “shape” files) of the mapped area, including classified data-layers.

4 Timing and progress reports

Provided that this proposal is accepted and a contract signed by both parties by 26 April 2022:

- NIWA will conduct the aerial mapping of *Agarophyton* spp beds before 30 June 2022, although the exact timing is dependent on suitable field conditions.
- NIWA will keep Otago Regional Council informed of progress via email during proposed weather windows
- NIWA will deliver a final report by 31 August 2022.
- NIWA anticipates being able to complete the project and provide Otago Regional Council with the project deliverables by 31 August 2022. If this cannot be achieved for whatever reason, NIWA will discuss with you the reasons for this and work with you to agree an appropriate adjusted timeframe.

5 Fees, expenses, and payment schedule

This project has been planned and priced according to NIWA’s standard rates. We have minimised our fees and expenses as far as is practical, consistent with achieving high operational efficiencies and delivering the project’s outputs to the highest professional standard. The personnel assembled for this project have been chosen to ensure that the project’s technical requirements, timeliness,

safety and quality will be satisfied at the lowest practical cost considering all reasonable and relevant factors and your requirements.

The estimated fees and expenses for the project total \$ 42,849 (excluding GST).

A breakdown of these fees and expenses is shown in Table 1.

Table 1: Fees and expenses summary.

Task	Fees and expenses (\$NZ)
Planning, logistics and field campaign	30,000
Analysis and reporting	12,849
Total (excluding GST)	42,849

The proposed payment schedule is shown in Table 1.

Table 2: Payment schedule proposed.

Payment/milestone	Fees and expenses (\$NZ)	Payment date
Completion of fieldwork	30,000	30 June 2022
Final report received	12,849	31 August 2022
Total (excluding GST)	42,849	

Following usual business practice, NIWA will invoice as milestones are achieved, with invoices falling due in accordance with the payment schedule.

5.1 Costs excluded from our pricing

The above fees and expenses **include** peer reviews by NIWA staff as part of our safety and quality management practice. There is no provision for external review of the sampling plans, data analyses and statistical methods, models and technical or final reports by other parties. Any revision to incorporate external feedback is likely to involve additional fees.

If comments are not received on the draft report within 1 month of delivery to Otago Regional Council, then the report will become the final version.

Our pricing does not include the modification, or interpretation of third party data in the comparison of aerial and manual *Agarophyton* spp bed delimitation. Furthermore, our reporting does not include interpretation of the causes of, or changes in *Agarophyton* spp distribution.

The costs provided in these budgets exclude GST and any costs associated with obtaining any necessary resource or other regulatory consents or approvals, unless specified above. Any such consents or approvals either will be arranged and paid by Otago Regional Council, or NIWA will obtain them and charge the client for this work based on actual time and expenses.

The fees and expenses are calculated based on the services as set out in this proposal. Any change in the services may result in a change in the fees and expenses accordingly. We are happy to provide further estimates on request.

6 The project team and responsibilities

The **Project Manager** will be Hamish Sutton who will perform all necessary planning and approval of aerial drone imaging and lead the fieldwork. Hamish is an experienced field technician with several years' experience flying a range of aerial drones for many freshwater, terrestrial and marine applications.

Dr. Stephanie Mangan will assist Hamish in the planning and completion of fieldwork, as well as contribute to the analysis and reporting. Stephanie has significant experience in estuarine ecology and will provide taxonomic experience in the identification of estuarine aquatic vegetation.

The project manager's role is to manage and lead the project on a day-to-day basis, to NIWAsafe standards, deliver contracted outputs (deliverables) on time, within budget, within scope and to the required quality, and maintain a good business relationship with the client.

The **Project Director** will be Dr. Leigh Tait who will advise Hamish and Stephanie on the parameters for aerial imaging, assist in the processing and analysis of aerial imagery and contribute to the final report. Leigh has significant experience in remote imagery capture, processing and analysis, and has been instrumental in the adoption of drones for enhancing the coverage of ecological monitoring.

The project director's role is to maintain a higher-level overview of this project to ensure that the objectives are met to your satisfaction, and contracted outputs (deliverables) are delivered on time, within budget, within scope and to the required safety and quality.

CVs for the project team are available upon request.

7 Project management, terms and conditions

7.1 NIWA's project management system and quality assurance system

As with all NIWA projects, this project will be managed within our comprehensive Project Management System. This controls progress, expenditure, hazards, quality and delivery.

The Project Management System also includes NIWA's in-house quality assurance system. NIWA is a member of the New Zealand Quality Foundation and part of the NZQF quality self-assessment accreditation programme.

NIWA's quality assurance system was developed specifically for its science-based activities. It utilises a rigorous peer-review quality assurance process. This process is integral to developing project proposals, reports and other deliverables. Review steps for each project include:

- at least one peer review of the proposal especially methods, approach, data management, analyses and resourcing;
- progress reviews, notably hours worked against total hours and milestone achievement, and
- review of project documents (e.g., technical or progress reports) prior to release.

The project management system is also integrated with NIWA's personnel performance and development management system. In addition, NIWAsafe is central to successful project management with hazard management activity at each stage of the project's management.

7.2 Stay Safe with NIWA

The health, safety, and wellbeing of NIWA people and our partners working with us is at the forefront of what NIWA stands for. It is a core value for NIWA. We believe that conducting our work safely and protecting people from harm is of paramount importance.

Our commitment is to always put safety first and manage our risks for the ultimate benefit of the health, safety, and wellbeing of our people. We continuously strive to achieve this through: (1) improving our safety leadership, (2) focusing on personal decision making, and (3) proving excellence in safety and wellbeing management.

Worker participation in NIWAsafe, our health and safety management system, is a central mechanism around which our project management work is planned and implemented. We maintain and actively update comprehensive safety information on our intranet which supports our Project Management System.

NIWAsafe policies, procedures, standards, and guidelines are focused on keeping our people safe and meet all risk management, legislative, and regulatory requirements and codes of practice including applicable Maritime, Aviation, and Hazardous Substance requirements. This includes duties of care and responsibility to our employees, contractors, clients, and the public. We work with our clients to their health and safety expectations. Our standard contractual terms reflect a shared approach to health and safety, with both parties having duties to consult on the identification, assessment and control of any hazards and risks associated with the project. The outcome of this shared approach is an agreed health and safety plan to manage those hazards and risks, that has involved workers in its design and implementation. The parties will continue to consult with each other to manage health and safety hazards, and risks throughout the contract, and will meet regularly to review health and safety practices and implications for contract delivery. We will notify the client of any health and safety incidents or events associated with the project.

Information regarding NIWAsafe practices is available by contacting the regional manager Phillip Jellyman at: phillip.jellyman@niwa.co.nz

All NIWA boating activities will operate under the NIWA Boating Code of Practice, which has the overall goal of achieving 'Safe and Successful Boating Operations' during the course of carrying out NIWA's research activities on NIWA-owned, or NIWA-contracted vessels. NIWA staff using boats hold commercial boating qualifications approved by Maritime NZ and have extensive field-based expertise. In addition to this, all NIWA boats are assessed in terms of their fitness for purpose and, as NIWA holds a Maritime Transport Operator Certificate (MTOC), are operated within the framework of the Maritime Operatory Safety System (MOSS).

Underwater diving has been identified by Work Safe NZ as a hazardous activity, and all NIWA divers have undergone full training and hold recognised certification for Occupational Scientific Diving. All authorised NIWA diving projects are conducted according to protocols laid down in the NIWA Code of Scientific Diving Practice (Diving Safety and Standards Manual). A copy of this code is registered with Work Safe NZ.

7.3 Insurance

NIWA carries comprehensive public liability and professional indemnity insurance coverage.

7.4 Intellectual property

Intellectual property originating from either party prior to the commencement of the contract, including that which is used for the purposes of providing the services, and all developments or adaptations of, shall remain the exclusive property of the party introducing that intellectual property.

Reports produced during the project, and paid for by Otago Regional Council, will be owned by the client.

Diagrams or images used in this report may be subject to copyright and unless otherwise agreed with NIWA must not be reproduced without permission from their creator.

NIWA and Otago Regional Council will reach an agreement between them regarding ownership and use of any models and other outputs or deliverables from the services. Generally, NIWA expects to retain ownership of any models or significant data sets used as part of its operations, or developed by it in order to perform the services, and all modifications, developments, or additions to those.

7.5 Terms of engagement

Reflecting standard business practice, unless otherwise agreed, NIWA will undertake the work pursuant to NIWA's standard terms and conditions. Where appropriate, a copy of these is attached to this proposal.

If those conditions are not acceptable to Otago Regional Council, then NIWA may negotiate alternative contractual terms on a case-by-case basis.

For the avoidance of doubt this proposal, even if accepted by Otago Regional Council, it does not constitute a contract, and NIWA will not be bound to provide the services until a formal contract has been entered into.

Any changes to the services, fees, or agreed personnel during the course of providing the services must be agreed to in writing.

- NIWA has not budgeted for external or peer reviews of the technical reports or final report by parties other than NIWA or the client.

7.6 Dependencies

NIWA's delivery of the proposed services and deliverables is dependent on:

- Weather conditions being suitable to undertake the fieldwork.

We note that we will plan contingencies around multiple broad "weather-windows" to limit the interruption by weather events.

7.7 Impact of COVID-19

In preparing this proposal we have sought to factor in the likely impacts of the COVID-19 pandemic on our ability to provide the services. NIWA has robust systems in place to try and mitigate the potential impacts of Covid-19. However, we recognise that there remains a

degree of uncertainty around how the COVID-19 crisis will progress and that even with good systems it may not always be possible to fully mitigate the impacts of Covid-19. Should any circumstances relating to COVID-19 affect the services or a party's performance of the contract, then our expectation is that that party will promptly notify the other party and the parties will negotiate in good faith appropriate variations to the contract as required to address the impact of these circumstances.

- Most of our office-based activities can be undertaken remotely by staff working from home. This includes activities such as data analysis and report writing.
- Should activities undertaken by NIWA staff be classified as essential services, a limited number of individuals will be authorised to continue to deliver these office, laboratory, and field-based services.
- The services covered in this proposal are not classified as essential services that could be authorised to continue.
- NIWA is willing to discuss with Otago Regional Council to try to accommodate any specific requirements it may have in relation to the management of COVID-19.

8 Validity

The proposal is valid for acceptance for 30 days from date of issue.

9 Confidentiality

This proposal, and the information it contains, is and shall remain the property of NIWA, and is to be treated as confidential. The information contained here may only be used (or disclosed) as reasonably necessary to assess NIWA's offer of services, for the inclusion of documentation for the engagement of NIWA, and for no other purpose. The proposal or any related information may not be disclosed to any third party without first receiving NIWA's express written consent.

10 Professionalism and ethical standards

NIWA prides itself on the professionalism of all its staff and is committed to operating to the highest possible standards, and complying with all applicable laws, regulations, and codes of conduct (including as to expert evidence). Staff are required to act ethically, and with honesty and integrity at all times, and in accordance with NIWA's Professional Conduct policies. These policies, among other things, require staff to communicate openly, honestly, and constructively considering confidentiality obligations, and treat others with courtesy and respect.

NIWA respects cultural values and diversity, with the recognition that our diverse workforce and stakeholders are part of NIWA's strength. We have a zero-tolerance approach to any instances of fraud, bribery, or corruption. NIWA regularly undertakes audits of our systems and legal compliance.

NIWA's policies prohibit NIWA staff members from accepting any gift, entitlement, or physical token of appreciation that is given or offered by any current or potential clients or suppliers without express approval from their regional manager.

Staff are required to declare any actual or potential conflicts of interest before commencing work on a project, and as soon as they emerge during the project. Staff are also required to consider whether NIWA itself has an interest in a matter that may conflict with a client's interests, and to remain alert

to situations where NIWA's different clients may have competing interests. Any conflicts of interest will be addressed immediately by the project manager and project director and, as appropriate, managed and resolved with the client.

11 Contact us

For more particulars, including discussion and/or negotiation on methods, price or deliverables, please contact:

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