Appendix J Front-end engineering design report

Ngāi Tahu Seafood Resources Limited

Hananui Aquaculture Project

Front-end Engineering Design report

Evidence of Dean Steinke regarding “Hananui Aquaculture Site – Front-End Engineering Design” and Proposed Consent Conditions

Dean Steinke, P.Eng.
11-20-2025

Introduction

My name is Dean Steinke.

My role in relation to the Hananui Aquaculture Project ("**HAP**") has been to provide expert evidence in relation to construction of net pens and moorings suitable for the marine environment . I was the lead author of the *Hananui Aquaculture Site – Front-End Engineering Design* report[1] which is provided within **Appendix J** of the application.

This evidence has been prepared to accompany the application by Ngāi Tahu Seafood Resources Limited ("**NTS**") for approvals required for the HAP under the Fast-track Approvals Act 2024 ("**FTAA**"). It has been prepared on the understanding that the process for determining applications under the FTAA does not require a hearing to be held, and accordingly the purpose of this evidence is to confirm that, relative to my area of expertise, the *Hananui Aquaculture Site – Front-End Engineering Design* provides an appropriate description of the relevant environment, the proposed activities comprising the effects of the HAP on that environment, and the way those effects are proposed to be managed.

My findings are set out in full in the *Hananui Aquaculture Site – Front-End Engineering Design* included within Appendix J of the application.

While this application is not being considered by the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2023 and that I have complied with it when preparing this evidence. Other than when I state I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Qualifications and Experience

I am a co-founder and CEO of DSA Ocean, a firm based in Victoria BC Canada specializing in the analysis of the marine environment and its impact on marine infrastructure. I lead a team of ocean engineers that works globally to support finfish aquaculture projects. We design, analyse, and verify the installation of finfish containment systems. I am intimately familiar with engineering requirements for aquaculture sites in Canada, Scotland, Norway, Chile, Australia and other countries around the world.

I graduated from the University of Victoria, with a Masters of Applied Science and undergraduate Bachelor of Engineering degree in Mechanical Engineering. My graduate work focused on the modelling of marine systems.

[1] The report was co-written under my direct supervision by Robert Baikkie, P.Eng. and Colin Wilson, P.Eng.

I have served as an expert witness on two separate occasions in the USA and the UK, related to the engineering of mooring systems and net pen design. I have assisted with the development the ISO 16488 marine finish standard.

I am registered with Engineering and Geoscientists BC as a Professional Engineer.

In providing this evidence in relation to the engineering of the containment structures and moorings for the HAP, I have considered the following matters as relevant to that topic:

- The project description provided by NTS as set out in section 6 of the application;
- The description of the existing environment, the effects of the HAP on that environment and their significance, and the proposed management and mitigation measures to manage those effects all as set out in the assessment of environmental effects accompanying the application;
- ADCP current meter data provided by NTS;
- MetOcean Solutions 2019. Hydrodynamic study of the Foveaux Strait. Report prepared for Cawthron, April 2019;
- Bennett H, Smeaton M, Floerl L, Casanovas P. 2025. Assessment of seabed effects associated with farming salmon offshore of northern Rakiura / Stewart Island. Prepared for Ngāi Tahu Seafood Resources; and
- "Tsunami hazard curves and deaggregation plots for 20 km coast sections, derived from the 2021 National Tsunami Hazard Model", WL Power, DR Burbridge & AR Gusman, GNS Sceince Report, 2022/61, 2023.

Confirmation of Contents of Report and Proposed Conditions

I confirm that in my opinion the *Hananui Aquaculture Site – Front-End Engineering Design* contains an accurate and appropriate description of the environment, the actual and potential effects of the HAP, and the recommended actions to manage those effects within my area of expertise.

I confirm that in my opinion the contents of the *Hananui Aquaculture Site – Front-End Engineering Design* may be relied on in making a decision on the approvals sought for the HAP and confirm that provided effects within my area of expertise are managed as proposed in the application those effects will not be unacceptable and will be managed to a standard that I consider meets good practice.

I confirm that I have reviewed the conditions that NTS proposes for the approvals being sought as they relate to my area of expertise. I confirm that in my opinion, those proposed conditions are appropriate.

X [redacted]

Dean Steinke, P.Eng.

2025-11-20

Document Title	**Hananui Aquaculture Site – Front-End Engineering Design Report**
File	DSA-NGAI-25FEED-R01-RevC Hananui Aquaculture Site- Front-End Engineering Design Report.docx
Revision	D
Prepared for	Ngāi Tahu Seafood Ltd
Client project no.	N/A
DSA project no.	NGAI-25FEED
Date created	2025-05-20
Pages (incl. cover)	54

Commercial in Confidence

DSA Ocean Pacific Office (Head Office)
201 – 754 Broughton Street
Victoria, BC V8W 1E1
+1.250.483.7207

DSA Ocean Atlantic Office
210 – 3600 Kempt Road
Halifax, NS B3K 4X8
+1.902.407.3722

info@dsaocean.com
www.dsaocean.com

Revision history

Revision	Date last revised	Summary of changes / Comments	Revisions by	Checked by	Approved for release by	Issued to / Distribution	Engineering review status (IFI / IFR / IFC)
A	2025-07-05	Initial draft report release for review by NTS	RB	CJW	CJW	NGAI TAHU Seafood Ltd.	IFR
B	2025-07-28	Final report release; updated Tsunami section and metocean conditions referencing OceanNum predicitons.	RB	DMS, CJW	CJW	NGAI TAHU Seafood Ltd.	IFR
C	2025-08-13	Updated 6.3.6 regarding the time in the production cycle with 19mm mesh; updated cage to net	RB	CJW	CJW	NGAI TAHU Seafood Ltd.	IFR
D	2025-11-06	Corrected Fig 2 & 14 to show a single barge per farm zone	RB	CJW	CJW	NGAI TAHU Seafood Ltd.	IFR

Engineering review status acronyms
IFI – Issued for Information
IFR – Issued for Review
IFC – Issued for Construction

List of authors / reviewers

Initials	Name
RB	Robert Baikie, P. Eng
DMS	Dean M. Steinke, P.Eng.
CJW	Colin J. Wilson, P.Eng.

Executive summary

DSA Ocean has developed the front-end engineering design for the proposed Hananui Aquaculture Project, located 2 km off the north coast of Rakiura (Stewart Island), New Zealand. Engaged throughout the development process, DSA Ocean has supported technology evaluation and feasibility assessment for farming operations in this region. For the project to be viable, farm equipment must demonstrate robustness under the site's unique metocean conditions and withstand potential interactions with wildlife such as seals, sharks, and seabirds. Accordingly, this report presents a summary of extreme wind, wave, and current conditions at the site, along with an evaluation of the required equipment.

The site layout was developed by Ngāi Tahu Seafood (NTS) with input from the Cawthron Institute and DSA Ocean, incorporating seabed characteristics, depositional modeling, surrounding marine ecosystems, and prevailing wave and current directions. Within the proposed area, four farm zones are planned, numbered 1 to 4 from the south. During Stage 1, each zone will include a single 2×5 grid of net pens and a feed barge. Stage 2 will add a second adjacent 2×5 grid in each zone, effectively doubling site capacity.

Each 10-pen grid will be secured to a submerged mooring grid (110 m × 110 m spacing) set at 6 m depth, which is itself moored to the seabed with an array of moorings and anchors. Net pens will be positioned at the center of each grid cell using bridles and feature industry-standard HDPE circular floating collars with a circumference of 168 m. Net structures are to be submerged in the water column to depths of 17 – 22 m below the surface, with a minimum clearance of 5 m from the seabed. These nets are designed for durability and resistance to predator incursions and marine mammal interactions. Feed barges serving the grids will be equipped with automated feeding systems, ensuring uninterrupted operation in poor weather.

To assess the viability of aquaculture at the site, metocean conditions were examined using data from three ADCP (Acoustic Doppler Current Profiler) deployments. Wave conditions used in the analyses were predicted using a 38-year hindcast wind and wave model. From these analyses, the maximum observed current speed was 1.12 m/s, maximum hourly mean wind speed at 10 m elevation was 26.62 m/s, and maximum significant wave height was 3.48 m. The seabed is primarily sandy in grid locations, making it highly suitable for anchoring using drag embedment anchors, which provide strong holding power when correctly installed.

Mooring analyses were carried out to verify the feasibility of securing both grids and feed barges under extreme environmental loading. These analyses were based on 1-in-10 and 1-in-50-year return period wind, wave, and current conditions. Forces on mooring components were calculated to determine appropriate material sizes and strengths, using design standards from ISO 16488 and following industry practices outlined in NS9415 and the Scottish Technical Standard. Conceptual mooring grid layouts were developed to confirm spatial fit within the proposed farming area. While mooring analysis was conducted on a single representative gird, this analysis applies to entire Hananui Aquaculture Project area. Should NTS need to relocate farms within the Hananui Aquaculture Project, to address environmental effects or for other reasons, then the proposed mooring, pen and barge parameters would be considered to remain appropriate for use.

Overall, DSA Ocean concluded that suitable net pen and barge systems are available through global suppliers such as AKVA and Scale AQ. These vendors provide equipment engineered to resist wildlife interactions and prevent fish escapes, supporting the engineering feasibility of the Hananui Aquaculture Project. Additional

design work, including compliance with relevant engineering standards and detail design will be undertaken post-consent grant based on the consent conditions.

Contents

Figures

Tables

1 Document Scope

DSA Ocean was contracted by Ngāi Tahu Seafood Ltd. to perform provide a front-end design of a marine finfish aquaculture facility for the Hananui Aquaculture site. The intention of this report is to demonstrate that net pen based aquaculture is feasible at this location. This report presents an engineering assessment of the design which was conducted to verify the suitability of the designed system's components for operations under projected metocean, or environmental, conditions at the site located near Stewart Island, NZ. This report summarizes the site location and farm layout, fish pen and mooring technologies, and metocean conditions at the site. To demonstrate the feasibility of the design from an engineering perspective, this report includes mooring analyses for both the grid systems and the feed barges and examines loads on the floating collars to ensure that the site can be safely constructed and operated. Information is provided of the environmental load cases applied to the system in the analysis, simulated component specifications, and both ultimate and accidental limit state results. The attached engineering drawings were developed as part of this work [9]. These include front-end engineering design specifications of the system based on the analysis results. The mooring system has been designed using ISO 16488 [2]. Guidance on processing environmental conditions followed NS9415 and the Scottish technical standards [1,3] as well.

2 Abbreviations and Acronyms

ADCP	Acoustic doppler current meter
ALS	Accident Limit State
DSA	Dynamic Systems Analysis Ltd.
FLS	Fatigue Limit State
HDPE	High-density polyethylene
Hs	Significant wave height
NTS	Ngāi Tahu Seafood
PE	Polyethylene
PET	Polyethylene terephthalate
UHMWPE	Ultra-high-molecular-weight polyethylene
ULS	Ultimate Limit State

3 Reference Documents and Drawings

[1]	"Norwegian Standard NS9415.E:2021: Marine fish farms: Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation.," Standards Norway, 2021.
[2]	"ISO 16488:2015: Marine finfish farms -- Open net cage -- Design and operation," International Organization for Standardization, 2015.
[3]	Marine Scotland, "A Technical Standard for Scottish Finfish Aquaculture," Ministerial Group for Sustainable Aquaculture's Scottish Technical Standard Steering Group, 2015.
[4]	DET NORSKE VERITAS (DNV), "Recommended Practice, DNV-OS-E301, Position Mooring," 2010.
[5]	"ISO 19901-7 – Stationkeeping systems for floating offshore structures and mobile offshore units," International Organization for Standardization, 2015.
[6]	https://www.hananuiaquaculture.co.nz/
[7]	Akva Group, "Product Certificate PS276", PS276 - Polarcirkel - Ø630-13.6-160_ENG_Låst.pdf, 2021

[8]	"ISO 14688-1:2017: Geotechnical investigation and testing – Identification and classification of soil" International Organization for Standardization, 2017.
[9]	DSA-NGAI-25FEED-D01-Rev.A-Hananui Aquaculture Site Drawings.pdf
[10]	https://tidalropes.com/product/anchors/
[11]	Bennett H, Smeaton M, Floerl L, Casanovas P. 2025. Assessment of seabed effects associated with farming salmon offshore of northern Rakiura / Stewart Island. Cawthron Report XXXX. Prepared for Ngāi Tahu Seafood Resources
[12]	MetOcean Solutions 2019. Hydrodynamic study of the Foveaux Strait. Report prepared for Cawthron, April 2019.
[13]	"oceanum_wave_nz1km_coastal_era5_param.nc," Dr. Peter McComb, Oceanum, 2025
[14]	"Tsunami hazard curves and deaggregation plots for 20 km coast sections, derived from the 2021 National Tsunami Hazard Model", WL Power, DR Burbridge & AR Gusman, GNS Sceince Report 2022/61, 2023

4 Hananui Aquaculture Project background

Ngāi Tahu Seafood (NTS) is in planning stages for building an offshore sustainable salmon farm under the name of Hananui Aquaculture. The proposed location is 2-6km off the northern coast of Rakiura (Stewart Island) as shown in Figure 1. This site was chosen because of its water quality and temperature, depth, strong currents, and areas of sandy seabed within the lease that have sparse amounts of sea life [6], among other reasons. NTS has focused on finding the most environmentally suitable location and systems to ensure the sustainability of the project. A key consideration for the project is that the chosen marine finfish farms technologies selected must limit interactions between seabirds, seals, and sharks with the farmed fish (e.g. predation, tearing of nets which would lead to fish escapes, and marine mammal entanglement).

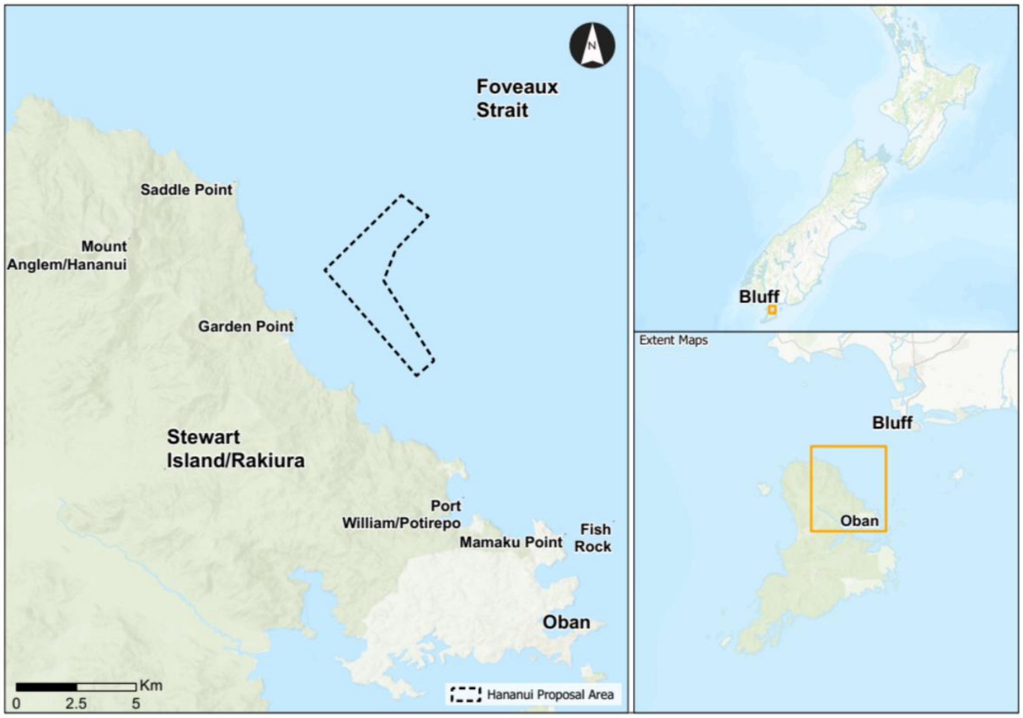


Figure 1. Hananui Aquaculture Site Location [6]

4.1 Location and site layout

The proposed fish farm lease area is located in the Foveaux Strait, near Stewart Island, NZ, as shown above in Figure 1.

Corners of the lease area are listed in Table 1.

Table 1. Lease Corner Coordinates

Corner	Latitude	Longitude
A	46°43'50.69"S	168° 3'58.60"E
B	46°44'21.00"S	168° 4'48.83"E
C	46°45' 3.65"S	168° 3'40.66"E
D	46°45'44.51"S	168° 3'13.27"E
E	46°47'36.70"S	168° 4'42.66"E
F	46°47'55.76"S	168° 4' 6.08"E
G	46°45'25.28"S	168° 1'19.09"E

Analysis of the environmental conditions of the site identified strong 1 in 50 year current conditions and moderate wave conditions as described in Section 5. Highlights of the environmental conditions for the engineering design considerations include:

- For all directions considered, the maximum of 1 in 50 year current speeds was 1.57 m/s towards the SE (140 degrees)
- Predominant wave direction was from NW and SE, with significant wave height (Hs) of approximately 3.02m.
- Highest probabilistic wave direction from which the maximum wave height condition to occur is from the East, with Hs = 3.48m

As shown in Figure 2, the grids have been oriented parallel with the shoreline, and inline with the dominant current conditions. This orientation is preferred to reduce the total overall drag loading on the farm, thus reducing mooring loads. The most extreme wave conditions are also likely to be parallel to the coastline, due to exposure and fetch from the northwest. Thus, similarly, the feed barges have been oriented in line with the highest probabilistic wave and current direction. This will allow for the highest probability of a head sea condition.

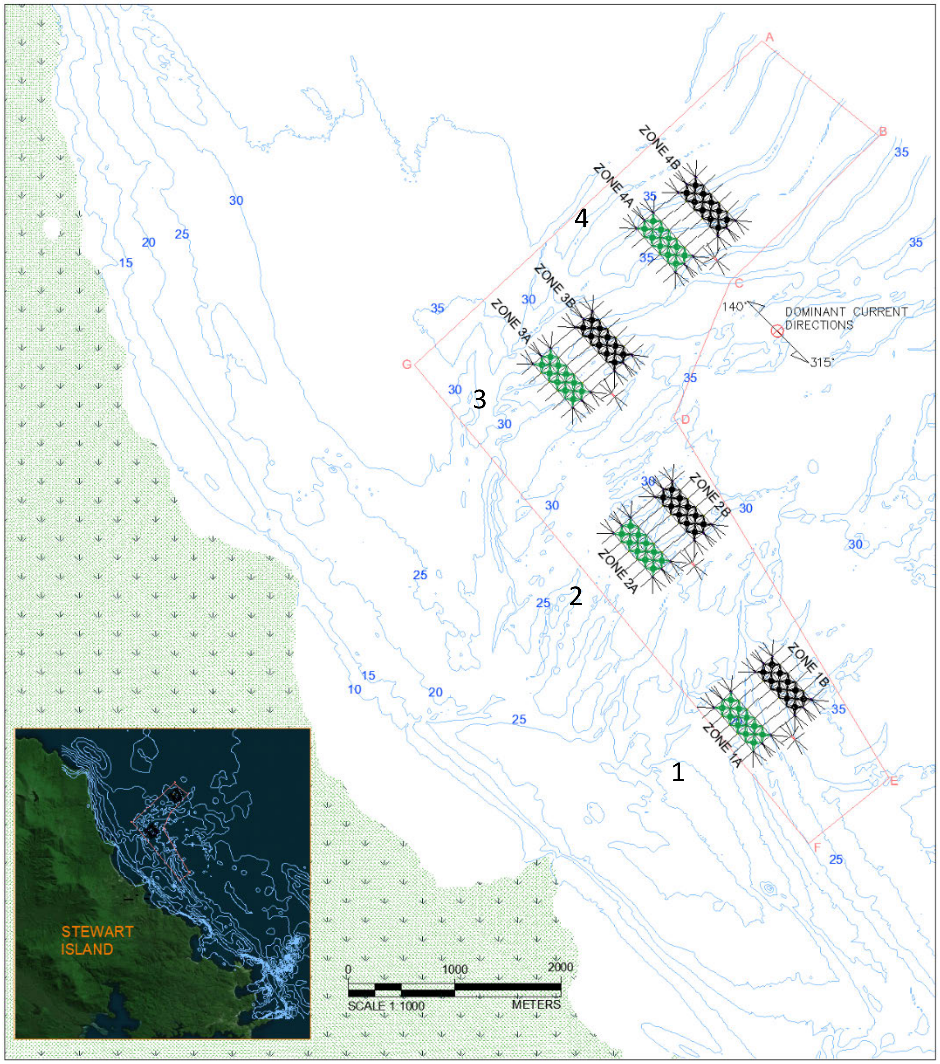


Figure 2. Bathymetry and Site Layout. The site consists of 4 farming zones with two mooring grid systems each. The low water water-depth is approximately 30m throughout the site.

4.2 Net pens and moorings

4.2.1 General description and requirements

Figure 3 illustrates a conventional circular net pen commonly used in fish farming. These net pens are anchored in place by a submerged mooring grid, as depicted in Figure 4. This style of aquaculture installation has been employed for decades and is widely used in all major fish farming regions globally. It has emerged as the best technology for high energy environments. A key element of the design is the use of high-strength, flexible high-density polyethylene (HDPE) pipe, which forms the floating collar that supports the fish-containing nets.

The design of a fish pen system for the Hananui Aquaculture Project—which includes both a floating collar and net pen—must meet the following general requirements:

- A floating collar with a circumference of 168 meters, offering sufficient strength and buoyancy to withstand current and projected loads while supporting the designated netting system
- A cylindrical net pen with a minimum height of 16 meters and 5m clearance wit the seabed
- Measures to prevent marine mammal entanglement and predation
- A mooring system with suitable compliance to accommodate currents, wave action, projected loads, and tidal fluctuations, while preventing fish escapes

The proceeding section provides further details on the construction and requirements of the nets, bird nets, floating collar and moorings.

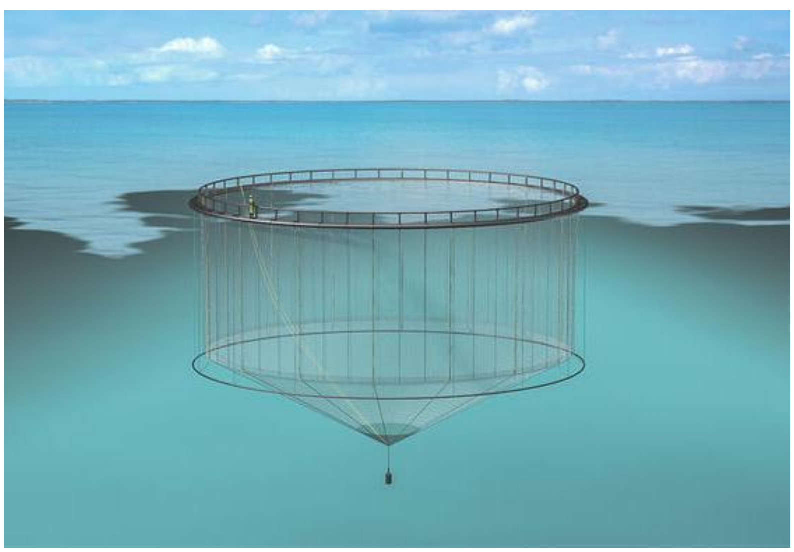


Figure 3. Net pen general configuration (AKVA)

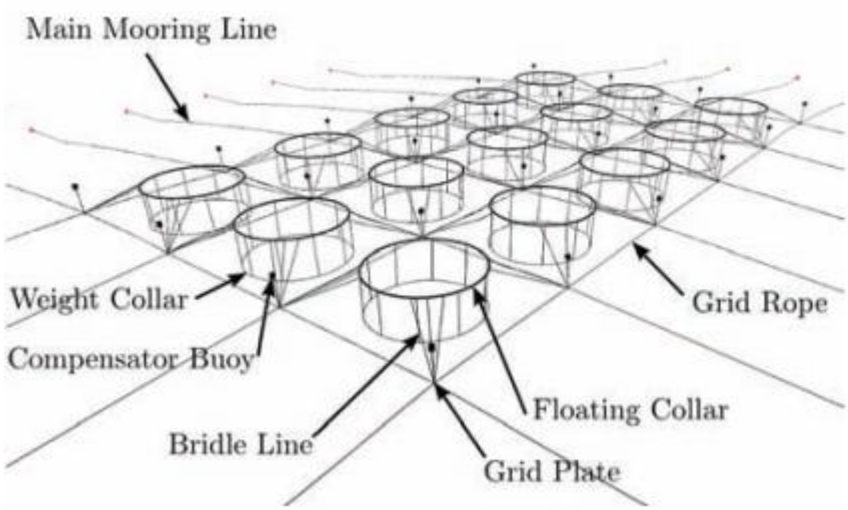


Figure 4. Conventional circular pen mooring grid

4.2.2 Fish nets

A cylindrical-style net pen, as generally illustrated in Figure 3 and Figure 6, has been selected for the project. The lower perimeter of the net pen is weighted with a submerged ring, while the conical bottom is anchored by a central weight. This bottom design is often integrated with a mort fish collection system to reduce predator attraction. Rib lines, also known as haul lines, are sewn into the nets to provide additional strength for supporting the weight ring or hauling the net upwards.

Multiple manufacturers produce these cylindrical net pens, and a broad range of commercial netting materials is available, each offering distinct properties and advantages. Among the latest innovations is stiff, predator-resistant netting made from high-density polyethylene (HDPE), which offers excellent abrasion resistance and tensile strength. HDPE netting also endures frequent cleaning and is available in both knotted and knotless configurations.

The mesh sizing used on for the net pens will vary with exact production planning but can range from 19mm to 32mm depending on grow-out stage from smolt to harvest. The 19mm mesh size is only required during the early stage of the grow out when smaller fish require a finer mesh for containment and protection. During the majority of the production period, significantly larger mesh sizes will be used.

The net pens typically will be configured to have a minimum clearance with the seabed. A profile of the net pen system is shown in Figure 5.

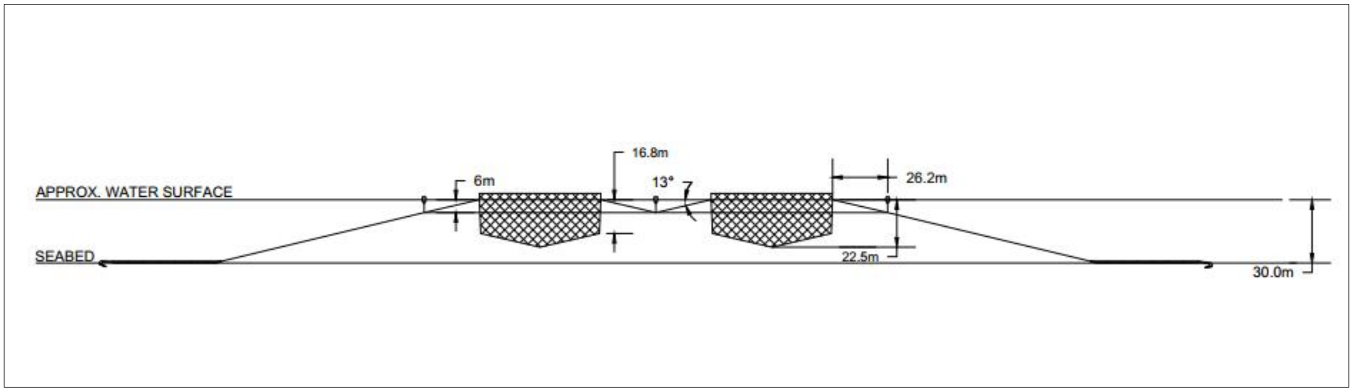
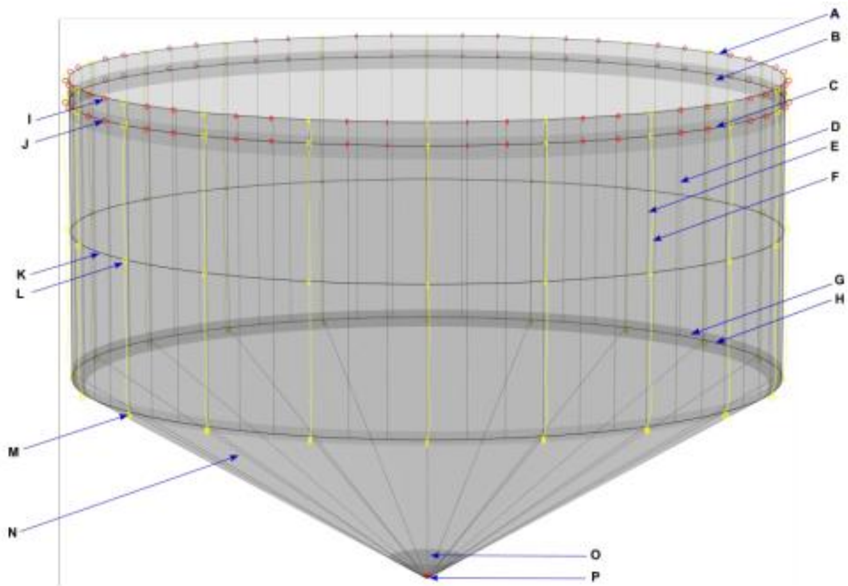


Figure 5. Profile view of the net pens under the water



Key

A Top rope (structural element)
B Waterline reinforcement area
C Main rope (structural element)
D Vertical rope (structural element)
E Lifting rope – vertical rope connected to a cross rope (structural element)
F Haul rope (non-structural element)
G Reinforcement area at side-to-bottom transition
H Bottom rope (structural element)
I Loop on top rope
J Loop on main rope (attachment point)
K Waistrope
L Loop on waistrope
M Loop on bottom rope (attachment point)
N Cross rope (structural element)
O Bottom reinforcement area
P Bottom centre

Figure 6. Fish farming net diagram and terminology as per NS9415:2021

4.2.3 Bird nets

Bird netting will be used to prevent birds from accessing fish in the pen. The mesh connects to the float collar and is supported by 65mm poles that are 5.9m high. The mesh used for the bird nets will be between 40mm and 60mm in size, depending on the best practices based on the local seabird species.

Mesh above the float collars is only exposed to wind loads. Because of the relative density of air compared to sea water and low drag profile of the nets, the loads from the top net and any netting above the float collar has been neglected in this analysis.

4.2.4 Floating collar

A conventional HDPE floating collar, with suspended net pen is proposed for the site, as illustrated in Figure 7 through Figure 10. The floating collar is responsible for supplying buoyancy to the net pen. Under high loading conditions, downward forces from bridles and mooring lines tend to pull the floating collars under the water if there is insufficient reserve buoyancy. When the collar gets pulled under water, it is exposed to increased loading from currents and waves, as well as increased risk for fish escapes. Therefore, it is important for the floating collar to have sufficient reserve buoyancy for all expected environmental conditions. Bridle loading is also a critical component when specifying these collars. As the drag on the net increases, so does the bridle load directly onto the float collars. For the Hananui Aquaculture Project, the use of a large diameter 630mm HDPE pipe in the floating collars was determined to be necessary for both strength and floatation. Manufacturers, such as Scale AQ and AKVA, can supply these floating collars which are certified to NS9415. A mix of galvanized steel or injection moulded brackets are used in the construction of brackets which tie the two floating pipes together.

Figure 7. AKVA Polarcirkel Stanchion (2 pipe system)

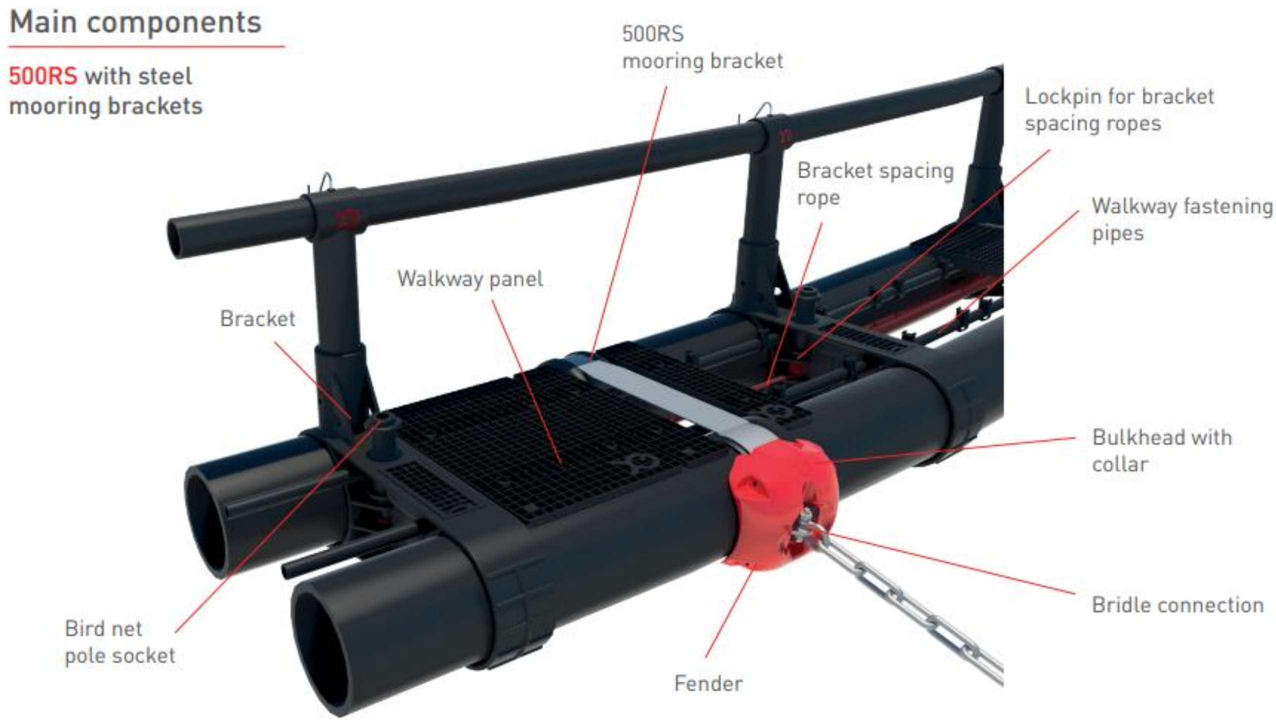


Figure 8. AKVA 500RS floating collar and brackets (stanchions)[1].

Figure 9. AKVA Polarcirkel 500R plastic pens

[1] Image from https://www.akvagroup.com/sea-based-aquaculture/pens-nets/plastic-pens

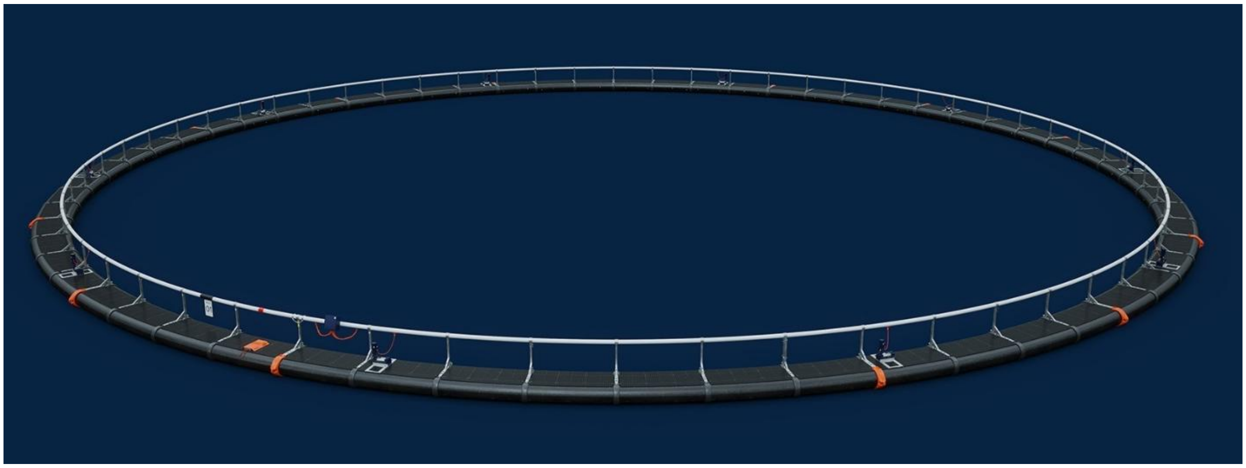


Figure 10. Scale AQ floating collar model[2]

4.2.5 Moorings and anchors

The mooring lines, which resist significant movement of the farm system and anchor to the seabed, must provide sufficient compliance to ensure the floatation of the system under the site's tidal range and wave action. The use of anchor chain in all mooring lines allows the chain to be lifted off the seabed in higher tides forming a catenary curve. Additional compliance is attained by the submergence of the outside compensator buoys at the grid corners of the system. A schematic of the anchoring for lead moorings is shown in Figure 11.

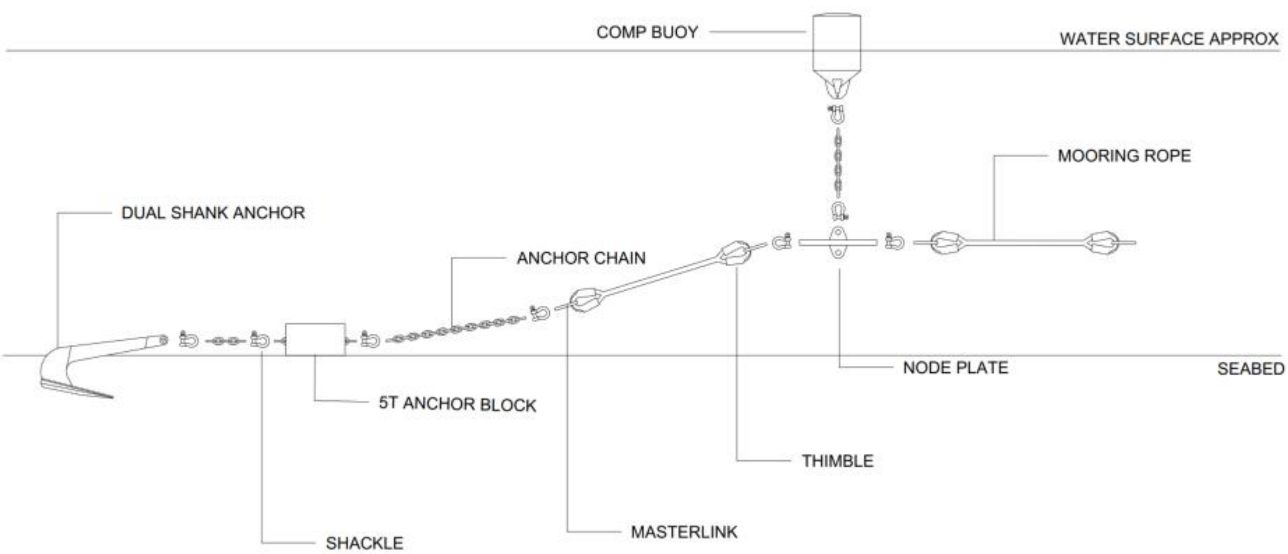


Figure 11. Mooring anchoring schematic

[2] Midgard® System - ScaleAQ

As noted in Section 5.1, for the Hananui Aquaculture site, these finfish pens are located above a sandy seabed which is ideal for the use of drag embedment anchor. These anchors require sufficiently deep sediment to provide their stated holding power. The angle at which the mooring line connects to the anchor also can affect the holding capacity. If the angle is too high, the vertical pull on the anchor may allow the drag type anchors to become loose and eventually drift. To combat this, concrete blocks or steel sinkers can be connected to the anchor chain close to the anchor end, as shown in Figure 11. This block helps the mooring line stay horizontal at its connection to the anchor, therefore pulling at the anchor in the way it is designed to. These anchor blocks can also provide additional compliance as they are lifted off the seabed, but this weight may cause the submergence of the leading collars. Simulations are required to ensure floatation of the pens is maintained while under high loading.

4.3 Feed Barges

Feed barges, as illustrated in Figure 12, will be installed at the proposed site to facilitate automated fish feeding. These barges are typically positioned at the head end of a grid, aligned with the farms. The AKVA AC 600 PV feed barge shown in Figure 12 is an example of the scale of feed barge required given its 600-tonne feeding capacity, enabling it to service a large number of pens. Key advantages include a high-capacity integrated tank system, robust design capable of withstanding significant wave heights up to 5 metres, and accommodation suitable for extended onboard stays. Dimension details are provided in Section 6.4.3. A mooring analysis for a representative feed barge, similar to AKVA AC 600 PV has been completed, with inputs and results detailed in Sections 6.3 and 6.5, respectively.

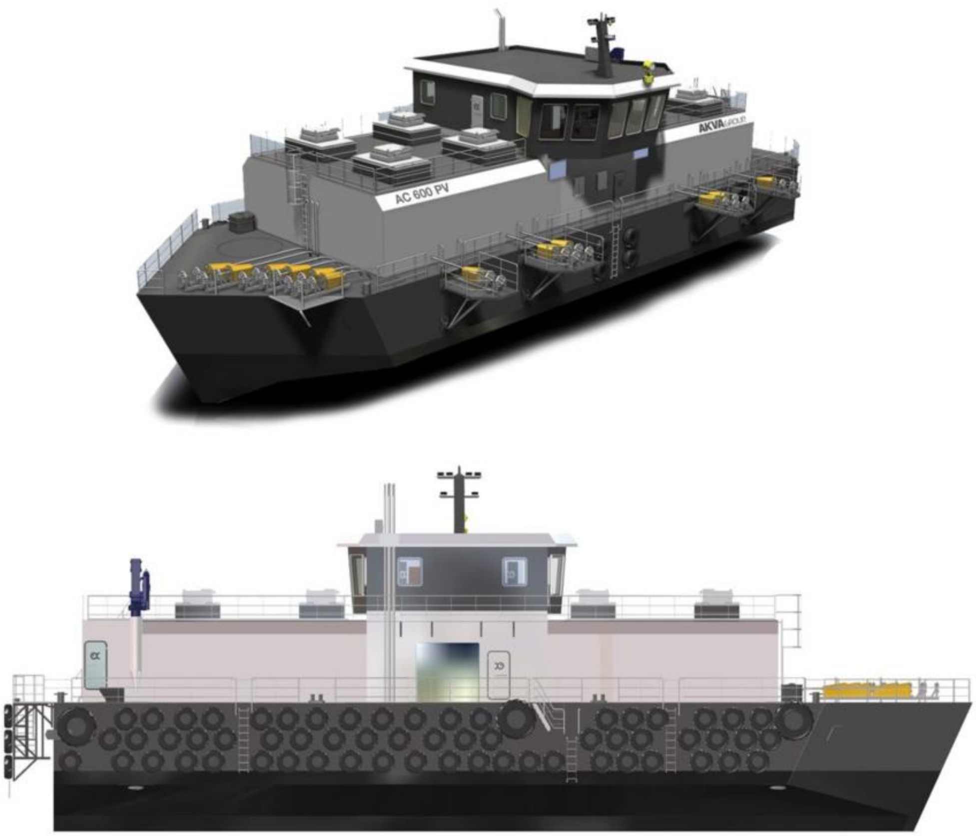


Figure 12. AKVA AC600 PV Feed Barge (Source: AKVA)

5 Metocean Conditions

5.1 Bathymetry, seabed & water depth

Bathymetry for Hananui Aquaculture Site is shown in Figure 2; the contour lines shown in the site layout drawing are based on multibeam data provided by Cawthron Institute and processed by DSA Ocean [11]. The seabed within the lease is relatively flat with shallower areas at 20m and deeper areas at 35m. The majority of the bathymetry within the lease is approximately 30m deep.

Based on a study completed by Cawthron Institute [11], the seabed in the lease area is composed mostly of sand as indicated in Figure 13. Per ISO14688 [8], sand is defined as particles ranging from 0.063mm to 2.0mm which can be further classified into coarse, medium, or fine sand. Based on DSA Ocean's experience, the sandy seabed can provide a high holding power for the anchoring systems planned for the project. It is recommended that the seabed sediment thickness should be verified using sub-bottom profiling, or other appropriate geotechnical investigation, prior to construction of a full grid on the site.

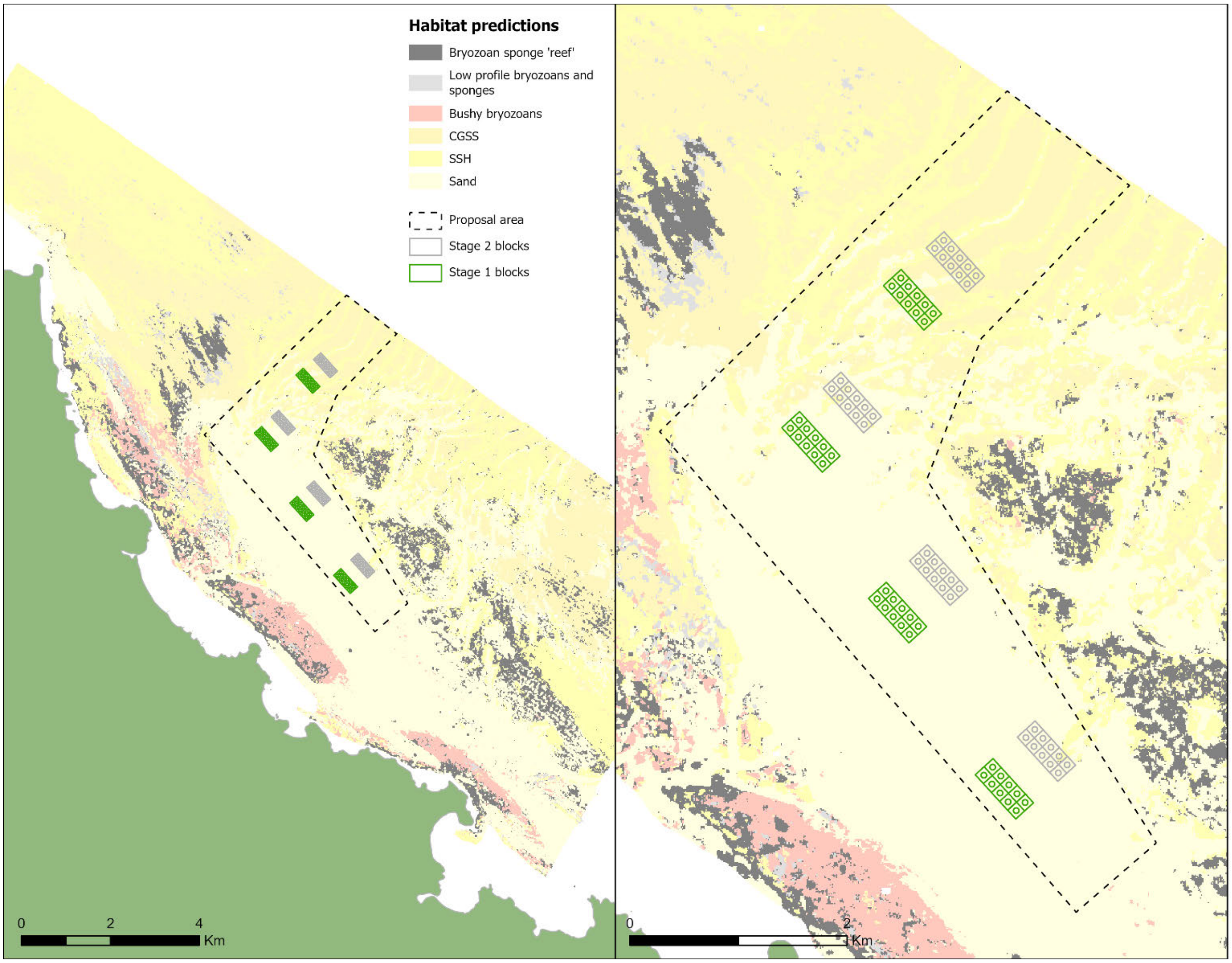


Figure 13. Seabed habitat type in fish farm lease area [11]

5.2 Wind conditions

Wind and wave design conditions were determined from a 38-year hindcast model of Stewart Island and surrounding areas by Metocean Solutions [12]. A grid point for the hindcast model closest to the center of the lease area was chosen.

Wind speeds were binned into eight octants around the compass, and then maximums were determined for each year in the hindcast. The yearly maximums in each bin were then used in an extreme value analysis using a Gumbel distribution to determine 10-year and 50-year return periods. These return periods are chosen as engineering standards, including NS9415[1] and ISO 16488[2], use load combinations based on these extreme values to create environmental conditions such that the probability of occurrence is sufficient low to be used as the basis for design.

The estimated 10 and 50 year wind speeds are provided in Table 2. Note, that these values are averaged over hourly periods and that in each period, a gust, which is a sudden increase and above average wind speed, may occur. Gust speeds are typically 25-35% higher than 1 hour mean speeds.

The maximum observed wind speed was 26.62m/s from the southwest with a projected 1 in 50 year wind speed of 29.46m/s in the same direction.

Additional hindcast modelling by Dr. Peter McComb with Oceanum has been completed for NTS to further verify the wind and wave conditions for the project. This hindcast model, reporting at the location the ADCP was deployed (See Section 5.4), produced lower maximum wind speeds for both the 10 and 50 year return period compared with the Metocean Solutions estimates. DSA Ocean completed its feasibility modeling of the farming equipment in Section 6 of this report, with the Metocean Solutions estimates. These higher wind speed values are more conservative, and the design presented will satisfy the conditions of the hindcast modelling estimates that Oceanum produced.

Table 2. Design wind speed. 1 hour mean speed at 10m elevation. Direction indicated in "from" convention.

Direction [from] [°]		Wind Speed (m/s) Max Observed	10 year return	50 year return
0	N	18.45	17.89	20.31
45	NE	18.96	16.29	18.96
90	E	19.33	18.63	21.9
135	SE	20.12	18.19	21.33
180	S	26.25	22.23	26.25
225	SW	26.62	25.44	29.46
270	W	24.38	23.19	25.63
315	NW	21.31	19.69	21.61

5.3 Wave conditions

Following the same analysis process as the wind conditions outlined above, the Metocean Solutions hindcast model [12] was processed to estimate the 1 in 10 and 50 year wave conditions for the site. Similar to the wind, these return periods were chosen as they are prescribed in relevant engineering standards [1,2] as the design criteria. The estimated extreme wave conditions are provided in Table 3.

The data shows maximum observed significant wave heights of 3.48m from the east and a projected 1 in 50 year significant wave height of 3.48m in the same direction.

Table 3. Design significant wave heights. Summary of 1 in 50 and 1 in 10 year return period Hs, and the maximum observed Hs. Direction indicated in "from" convention

Direction [from] [°]		Hindcast Hs (m)	Hindcast Tp (s)	10 year return Hs (m)	10 year return Tp (s)	50 year return Hs (m)	50 year return Tp (s)
0	N	1.82	6.00	1.67	3.60	1.89	6.00
45	NE	1.67	3.82	1.47	3.82	1.71	3.82
90	E	3.48	5.00	2.76	4.07	3.48	5.00
135	SE	2.97	6.03	2.46	6.03	3.02	6.03
180	S	1.49	10.95	1.68	10.95	2.47	10.95
225	SW	1.55	10.16	1.52	10.16	1.76	10.16
270	W	1.77	9.00	1.78	9.00	2.06	9.00
315	NW	2.45	8.50	2.12	8.50	2.29	8.50
Maximum Hs		**3.48**		**2.76**		**3.48**	

Similar to the wind modelling, Oceanum's hindcast modelling estimates of the wave conditions were reviewed. The design values for a 10 and 50 year return period were lower for the Oceanum hindcast model, with the maximum significant wave height of less than 2.5m rather than 3.5m. The predominate wave directions in both models were compared and found to be in agreement. As the analysis in Section 6 has been completed based on the higher, more conservative Metocean Solutions model predictions, this design will satisfy the conditions from the Oceanum model.

5.4 Current

Three ADCPs were deployed at or near the lease area. Current conditions used for the design of the Stewart Island fish farm site were determined from the Teledyne Sentinel ADCP deployed near the lease at 46°45'24.23"S, 168° 4'0.37"E (see Figure 14). This ADCP was chosen for design conditions as it recorded the highest currents of the three, and would lead to the most conservative specifications for the site. The Sentinel ADCP was deployed for 39 days between December 2018 and January 2019.

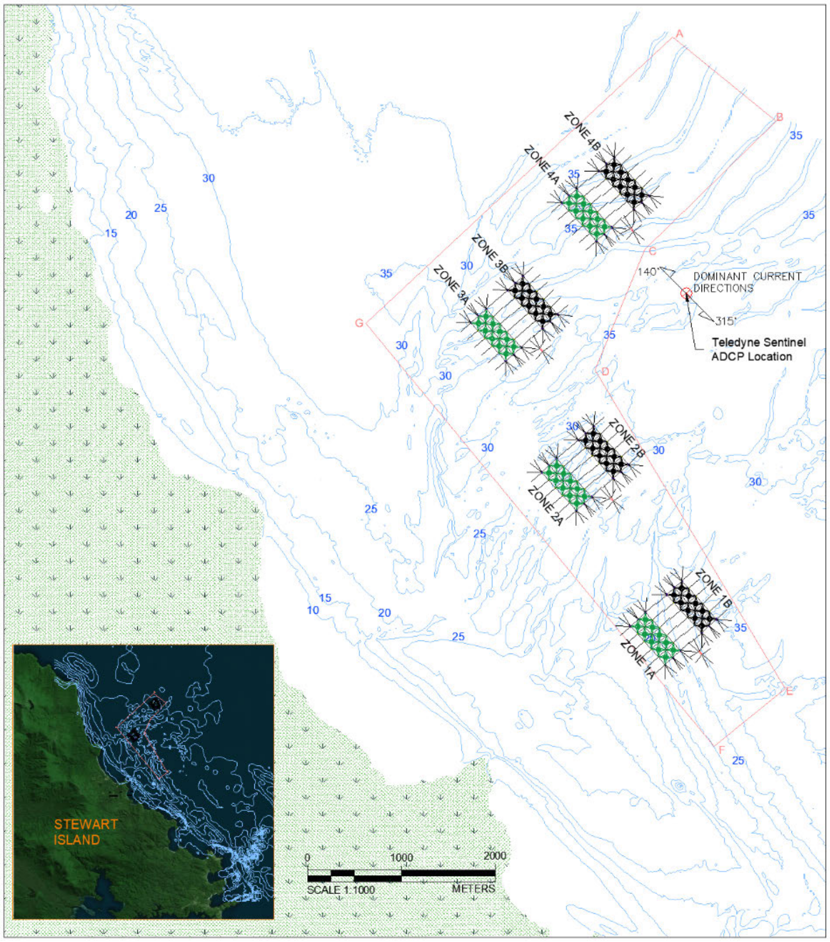


Figure 14 Teledyne Sentinel Location

Current velocities were binned into eight octants around the compass for 5m and 15m depths below the surface. Maximum current velocities were determined for each bin and scaled according to the guidance from the Scottish technical aquaculture standard assuming a strongly tidal site [3] and a standard practice for determining 10-year and 50-year return periods. Design current conditions for 5m and 15m depth are presented in Table 4.

The predominant current directions were determined to be towards the northwest (315°) and southeast (140°), roughly following the coastline of Stewart Island at the site.

The maximum measured current was found to be 1.12m/s towards 315° at 15m depth. The secondary current was 1.05m/s from 140° at 5m depth. The maximum 1 in 50-year current was determined to be 1.568m/s towards 315°. The summary of these conditions can be found in Table 20.

Table 4. Design current conditions (5m & 15m). Direction indicated in "towards" convention.

Direction [to] [°]		Observed		10 year return		50 year return	
		5m Depth	15m Depth	5m Depth	15m Depth	5m Depth	15m Depth
0	N	0.720	0.080	0.900	0.100	1.008	0.112
45	NE	0.300	0.060	0.375	0.075	0.420	0.084
90	E	0.360	0.040	0.450	0.050	0.504	0.056
140	SE	1.050	0.910	1.313	1.138	1.470	1.274
180	S	0.400	0.300	0.500	0.375	0.560	0.420
225	SW	0.260	0.110	0.325	0.138	0.364	0.154
270	W	0.630	0.150	0.788	0.188	0.882	0.210
315	NW	1.080	1.120	1.350	1.400	1.512	1.568

To further verify the current conditions spatial variation across the site, Figure 15 and Figure 16 provide two examples of modeled flow patterns in the vicinity of the proposed salmon farm, and performed by Oceanum. These figures show the depth averaged current speeds and directions near the peak of a flood tide and an ebb tide, respectively. In each figure, the the depth-averaged current speeds is shown by color gradient and black arrows show the current vectors. It is expected that the depth averaged current speed within the proposed farm is up to 1 m/s during the peak of both flood and ebb tides.

Overall these figures give confidence that the current conditions will not vary substantially across the lease, however it is recommended due to the high current speeds that prior to final engineering that an ADCP be deployed at the northern end of the lease for one year to better resolve the maximum expected current speeds. Longer current meter deployments can be used to lower the estimate of the maximum 1 in 50 year current conditions, which will result in more economical anchoring of the system.

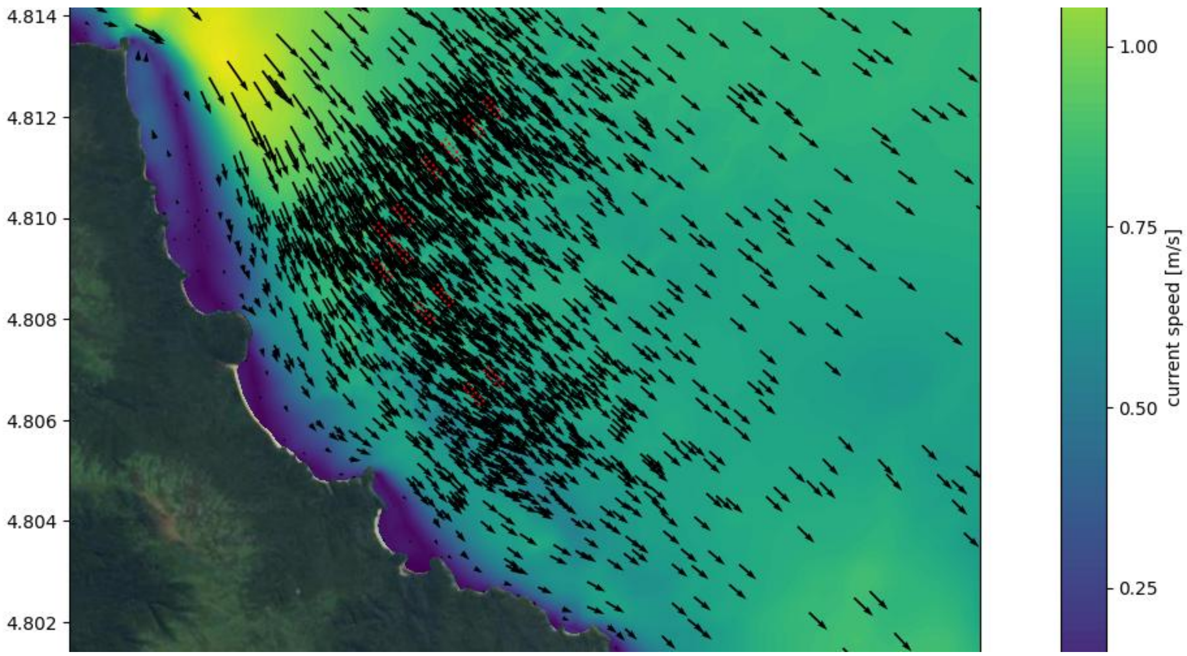


Figure 15. Flow pattern near the peak of a flood tide

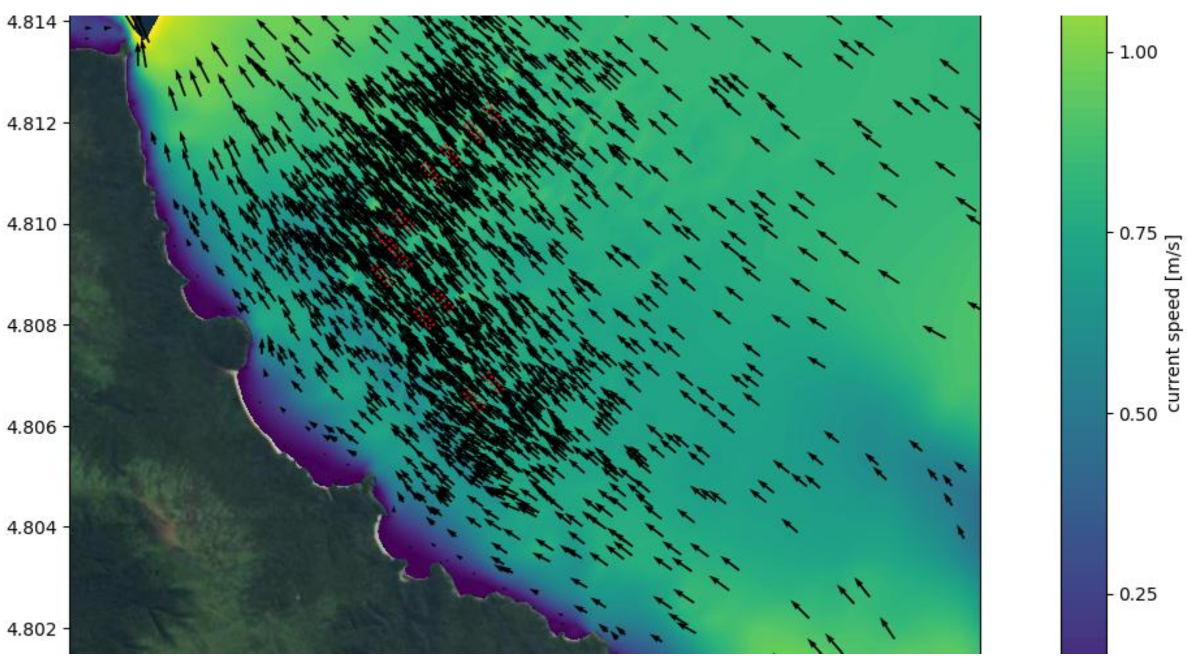


Figure 16. Flow pattern near the peak of an ebb tide

5.5 Tidal range

The tidal range at the site was noted to be 2.4m by Cawthron Institute. This tidal range can be handled by the compliance in the mooring systems as described in Section 4.2.5.

5.6 Tsunami

Current aquaculture and offshore mooring standards lack specific guidance on how to apply tsunami-related load cases or size equipment accordingly. Significant uncertainty remains regarding the return periods of such events, as well as the complex interplay between tides, water levels, and tsunamis. Nonetheless, it is prudent to consider the resilience of farm structures to these rare events.

GNS Science has conducted an assessment of the tsunami wave amplitude over a range of return periods for New Zealand, including the project location [14]. From this assessment, a tsunami wave amplitude of 2.6m is predicted for a 500 year return period, which corresponds to less than a 10% risk of occurrence during the lifespan of the project. From shallow wave theory, an associated current surge of 1.43m/s can be calculated.

Conservatively, this has been treated as a quasi-static case where the tsunami amplitude is modelled as a water level rise given the long wave period associated with tsunamis. The surge due to the tsunami was then applied to the displaced model as a uniform current.

It was assumed that current directions for the tsunami cases align with those observed in the ADCP survey, corresponding to predominant flow patterns during water exchange events in Foveaux Strait. Two ALS cases were subsequently modeled with the farm assumed to be in an intact condition under this estimated tsunami scenario (see Section 6.3.3).

6 Mooring Analyses

6.1 Mooring analysis method

6.1.1 Overview

Based on the generical system design determined and outlined above, mooring analyses were carried out using the software package ProteusDS. The purpose of the mooring analysis is to verify that the farm can be safely moored in the planned location. ProteusDS uses advanced hydrodynamic and finite-element models to predict the loads on the fish farm and feed barge mooring system under different environmental conditions.

The net loads and deflections were modeled using a finite element net model. The nets are modeled with consideration to wake shielding effects. As per NS9415, nets used for numerical simulations should include a 50% increase in twine diameter to account for fouling effects. Mooring lines, grid lines, bridles, and float collars were modeled using the finite element cable model. Buoys are modeled using a 6DOF rigid body model. Mechanical properties of net and cable materials were determined using accepted methods in applicable engineering standards [4, 5].

The feed barge was modeled using a 6DOF rigid body model. Wave radiation, diffraction, and added mass coefficients were determined using NEMOH, which is a Boundary Element Methods (BEM) code dedicated to the computation of first order wave loads on offshore structures. Coefficients determined in NEMOH were supplied to the ProteusDS model via a lookup database (i.e. Load RAO).

Two sets of analysis were completed as per NS9415 [1]:

- Ultimate limit state (ULS)
- Accidental limit state (ALS)

Each analysis determined resulting forces on mooring components and were compared with the required minimum breaking loads and safety factors.

The purpose of the ultimate limit state analysis is to ensure the mooring can withstand forces from expected long term extreme environmental conditions. Simulations were performed to demonstrate that the moorings withstand the design forces as specified in the load cases.

The purpose of the accident limit state analysis is to ensure the mooring can remain intact when components are accidentally damaged.

Examples of accidental load cases are:

- Breaks in mooring lines.
  - Breaks in lines carrying the largest load.
  - Breaks in lines which are critical for strength of the fish farm.
  - Breaks in the connecting points, such as the coupling plate.
  - Breaks in lines that are critical for positioning of single or groups of pens with common moorings, where relocation can lead to damage to other pens.
- Puncturing, disappearance or loss of floating parts.
  - Water penetration in one floating element.
  - Loss of one floating element at a most critical place.
- Spring Tide
  - The water level should be raised 1 meter above the upper tidal level.

Fatigue limit state was not considered at this stage in the design process. Fatigue limit state should be considered in the final design stage of the mooring. Experience has shown that fatigue rarely drives the design of the mooring system.

6.1.2 Component MBL Requirements

Each mooring component must satisfy the following condition:

$$F_{max} \leq \frac{MBL}{\gamma_f}$$

where F_{max} is the maximum force acting on the component found through simulation, MBL is the minimum breaking load of the component, and γ_f is the safety factor.

Safety factors for different mooring components are presented in Table 5, which are based on DSA's experience and recommendations from accepted standards [4, 5].

Table 5. Safety Factors for ULS and ALS Simulation Cases [2]

Mooring component	γ_f (ULS)	γ_f (ALS)
Synthetic ropes	1.67	1.25
Chains and chain components	1.67	1.25
Coupling plates and other steel connector elements	4.6	4.0
Anchors, rock pins	1.5	1.0

6.2 Grid mooring system model configuration

The following section outlines the model inputs for the analysis. Note that these inputs may not indicate the finalized specifications or as-built information (e.g. MBL, chain size, rope size) for the mooring system.

6.2.1 Grid

A schematic of the mooring system simulated in the analysis is provided in Figure 17.

Table 6. Circular net pen general arrangement

	Value	Notes
Number of mooring lines	30	
Net pen grid	2x5	
Number of net pens	10	
Net pen inner circumference	168 m	
Cell size (length x width)	110 m x 110m	
Grid total length	550 m	
Grid total width	220 m	
Grid depth	6 m	
Farm Orientation	42°	
Water elevation from chart datum	0 m	Bathymetry data is based on low water, and no adjustment

Table 7. Grid /system corner coordinates

Corner	Latitude	Longitude
NW	46°44'35.93"S	168° 3'19.08"E
SW	46°44'49.60"S	168° 3'35.68"E
SE	46°44'45.03"S	168° 3'46.64"E
NE	46°44'31.36"S	168° 3'27.03"E

Table 8. Mooring line start and end coordinates, horizontal distance and anchor depth

Mooring line	Latitude	Longitude	Anchor Lat	Anchor Long	Anchor depth (m)	Azimuth (deg)
1	46°44'35.93"S	168° 3'19.08"E	46°44'35.68"S	168° 3'15.10"E	30	273.0
2	46°44'35.93"S	168° 3'19.08"E	46°44'37.69"S	168° 3'16.01"E	30	228.0
3	46°44'38.66"S	168° 3'22.40"E	46°44'40.46"S	168° 3'20.78"E	30	228.0
4	46°44'41.40"S	168° 3'25.72"E	46°44'43.16"S	168° 3'22.65"E	30	228.0
5	46°44'44.13"S	168° 3'29.04"E	46°44'35.68"S	168° 3'15.10"E	30	228.0
6	46°44'46.86"S	168° 3'32.36"E	46°44'48.62"S	168° 3'29.29"E	30	228.0
7	46°44'49.60"S	168° 3'35.68"E	46°44'51.36"S	168° 3'32.61"E	30	228.0
8	46°44'49.60"S	168° 3'35.68"E	46°44'52.33"S	168° 3'35.32"E	30	183.0
9	46°44'49.60"S	168° 3'35.68"E	46°44'51.71"S	168° 3'38.24"E	30	138.0
10A	46°44'47.31"S	168° 3'39.66"E	46°44'49.63"S	168° 3'41.80"E	30	145.5
10B	46°44'47.31"S	168° 3'39.66"E	46°44'49.42"S	168° 3'42.22"E	30	138.0
10C	46°44'47.31"S	168° 3'39.66"E	46°44'49.18"S	168° 3'42.60"E	30	130.5
11	46°44'45.03"S	168° 3'43.64"E	46°44'47.14"S	168° 3'46.20"E	30	138.0
12	46°44'45.03"S	168° 3'43.64"E	46°44'45.28"S	168° 3'47.62"E	30	93.0
13	46°44'45.03"S	168° 3'43.64"E	46°44'43.27"S	168° 3'46.70"E	30	48.0
14	46°44'42.30"S	168° 3'40.32"E	46°44'40.54"S	168° 3'43.38"E	30	48.0
15	46°44'39.56"S	168° 3'37.00"E	46°44'37.80"S	168° 3'40.06"E	30	48.0
16	46°44'36.83"S	168° 3'33.68"E	46°44'35.07"S	168° 3'36.74"E	30	48.0
17	46°44'34.10"S	168° 3'30.36"E	46°44'32.34"S	168° 3'33.42"E	30	48.0
18	46°44'31.36"S	168° 3'27.04"E	46°44'29.60"S	168° 3'30.10"E	30	48.0
19	46°44'31.36"S	168° 3'27.04"E	46°44'28.63"S	168° 3'27.39"E	30	3.0
20	46°44'31.36"S	168° 3'27.04"E	46°44'29.25"S	168° 3'24.47"E	30	318.0
21A	46°44'33.64"S	168° 3'23.06"E	46°44'31.32"S	168° 3'20.92"E	30	325.5
21B	46°44'33.64"S	168° 3'23.06"E	46°44'31.54"S	168° 3'20.50"E	30	318.0
21C	46°44'33.64"S	168° 3'23.06"E	46°44'31.78"S	168° 3'20.12"E	30	310.5
22	46°44'35.93"S	168° 3'19.08"E	46°44'33.82"S	168° 3'16.52"E	30	318.0

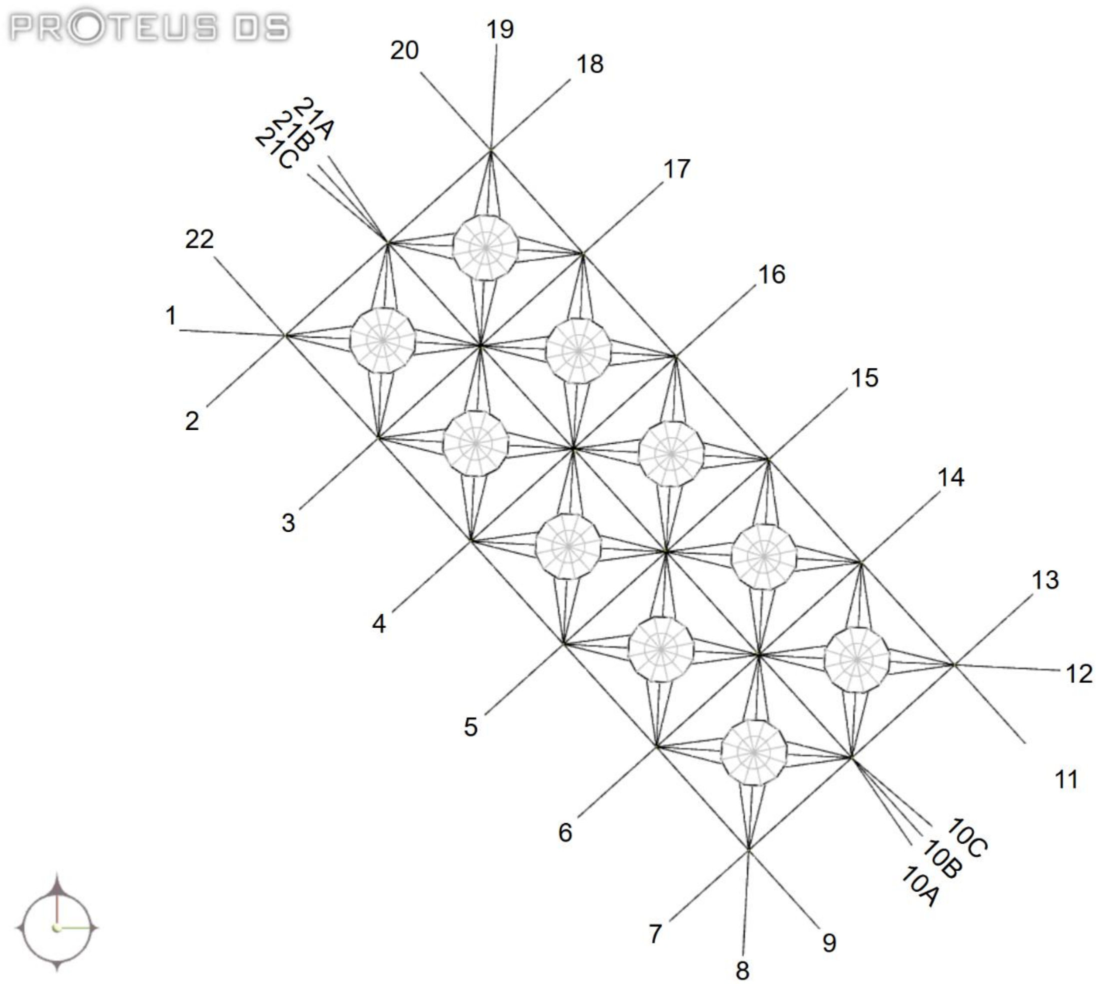


Figure 17. Net pen mooring system

6.2.2 Mooring lines

Materials used for the mooring analysis are listed in Table 9. Deviation from these materials (e.g. size, MBL, rope construction, chain weight) may affect the loads reported by the analysis.

Table 9. Mooring line & rib line segment properties

Mooring materials	Use	Mass in air (kg/m)	Weight in water (kg/m)	EA (N)
50mm studlink chain	Mooring Chain	57.0	49.3	219,911,486
80mm co-polymer	Mooring Rode & Grid Line	2.90	-0.37	5,666,266
24mm co-polymer	Rib Line	2.59	-0.03	539,385

Table 10. Mooring analysis model mooring line configuration

Line #	Total Length (m)	Rope (m)	Rope material	Bottom Chain (m)	Bottom chain material	Pretension (kN)
1	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
2	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
3	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
4	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
5	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
6	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
7	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
8	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
9	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
10A	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
10B	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
10C	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
11	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
12	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
13	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
14	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
15	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
16	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
17	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
18	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0

19	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
20	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
21A	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
21B	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
21C	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0
22	91.8	36.8	Co-polymer 80mm	55	G2 50mm studlink	5.0

6.2.3 Buoys

Compensation buoys used in the analysis are described in Table 11 and Table 12.

Table 11. C1 - Buoy properties

Brand / model	Generic
Net buoyancy	6600 kg
Mass	1300 kg
Length	2.32 m
Diameter	2.32 m
Brand	Generic

Table 12. C2 - Buoy properties

Brand / model	Generic
Net buoyancy	2200 kg
Mass	400 kg
Length	1.61 m
Diameter	1.61 m
Brand	Generic

6.2.4 Mooring nodes

The mooring node used in the analysis is described in Table 13.

Table 13. Node properties

Brand / model	Generic
Mass	221 kg
Material	Steel

6.2.5 Float collars

The float collars used in the analysis are described in Table 14.

Table 14. Float collar

Brand / model	AKVA 630
Pipe diameter	630mm
Number of pipes	2
Distance between pipes	1.6
SDR	13.6
Mass / length in air (kg/m)	639 kg
Net buoyancy (kg/m)	477 kg/m (estimate)
Handrail height	1.0 m
Bridle axial load rating (ULS)	306 kN [7]
Bridle axial load rating (ALS)	390 kN [7]
Bridle vertical load rating (ULS)	76 kN [7]
Bridle vertical load rating (ALS)	91 kN [7]

6.2.6 Bridles

The bridle configuration used in the analysis is described in Table 15 and their properties are reported in Table 16.

Table 15. Bridle configuration

Number of bridles	3 bridles per node
Angles	5 degrees (horizontal)
Distance between connections on floating collar	3 m

Table 16. Bridle line properties

	Mass in air (kg/m)	Weight in water (kg/m)	EA (N)
72mm co-polymer	2.34	-0.30	4,603,841

6.2.7 Nets

The net pens are a cylindrical shape, with a cone attached to the bottom. Analysis was run on a single containment net using the smallest mesh size, 19mm. This mesh size was chosen as it will produce the higher loading than larger mesh sizes. Details of the net analyzed are presented in Table 17.

Rib lines, running from the float ring to the weight ring, via the net, provide structure to the net pen. The details of the rib lines analyzed in presented in Table 18.

Table 17. Net properties

Net Type	Containment
Material	HDPE
Twine Diameter (mm)	3.0
Effective twine diameter with 50% fouling (mm)	4.5
Half mesh (mm)	19
Solidity (%)	31.6%
Solidity with fouling (per NS9415) (%)	47.4%
Cylinder Top Diameter (m)	53.5
Cylinder Bottom Diameter (m)	53.5
Cylinder height (m)	16
Cone height (m)	6
Total net height (m)	22
Number of rib lines	16

Table 18. Rib line properties

	Rib line material	Mass in air (kg/m)	Weight in water (kg/m)	EA (N)
Containment	24mm co-polymer	2.59	-0.03	539,385

6.2.8 Weighting system

A weighting system is used to reduce net deflection from current loading. A weight ring, filled with ballast, was the system considered in this analysis. The ballast analyzed was a complete fill of concrete. The properties of the weight ring used in this analysis are listed in Table 19.

Table 19. Weight ring

Pipe diameter (mm)	315
Number of pipes	1
SDR	11
Mass / length in air (kg/m)	149.81
Weight in water (kg/m)	69.93
Fill Material	Concrete

6.2.9 Bird Nets

The loading on the system is dominated by the current speed that the system is exposed to with dynamic loaded due to the waves. Given the limited windage of the system, the wind loads contribute a neglectable amount to the mooring load of the system. For this reason and for model simplicity, bird nets have not been modelled in this analysis. This includes the bird net, jump fence and any other mesh that is above the float collar.

6.3 Grid mooring system analysis results

6.3.1 ULS load cases

A list of ULS load cases is presented in Table 20. For the two dominant current headings of 315 and 140 degrees, the load cases with the closest heading to the two dominant headings were adjusted to match the exact heading, as shown in blue in Table 20 below. This was done to ensure the exact current heading for the most dominant directions were used to produce more accurate loading results in ULS simulations.

For the extreme value analysis completed on significant wave heights and wind speeds, the design 50-year condition was chosen based on the greater value between the 50-year predicted value and the maximum observed value. In some cases, the maximum observed value from the hindcast was greater than the predicted 50-year return period value.

These load cases were used for the feed barge mooring system and the grow-out net pen mooring system.

Table 20. ULS Load Cases

	Case	Heading [to] (deg)	Current (m/s)		Wind (m/s)	Hs (m)	Tp (s)
			5 m	15 m			
50yr current, 10yr wave/wind	ULS 01	0	1.01	0.11	22.23	1.68	3.60
	ULS 02	45	0.42	0.08	25.44	1.52	3.82
	ULS 03	90	0.50	0.06	23.19	1.78	4.07
	ULS 04	140*	1.47	1.27	19.69	2.12	6.03
	ULS 05	180	0.56	0.42	17.89	1.67	10.95
	ULS 06	225	0.36	0.15	16.29	1.45	10.16
	ULS 07	270	0.88	0.21	18.63	2.76	9.00
	ULS 08	315*	1.51	1.57	18.19	2.46	8.50
10yr current, 50yr wave/wind	ULS 09	0	0.90	0.10	26.25	2.47	6.00
	ULS 10	45	0.38	0.08	29.46	1.76	3.82
	ULS 11	90	0.45	0.05	25.63	2.06	5.00
	ULS 12	140*	1.31	1.14	21.61	2.45	6.03
	ULS 13	180	0.50	0.38	20.31	1.89	10.95
	ULS 14	225	0.33	0.14	18.88	1.71	10.16
	ULS 15	270	0.79	0.19	21.90	3.48	9.00
	ULS 16	315*	1.35	1.40	21.33	3.02	8.50

6.3.2 ULS results

The ultimate limit state (ULS) analysis was completed with the load cases described in Table 20. Load case ULS 08 produced the highest loads on the mooring lines, as shown in Figure 18. A summary of the maximum tensions for the mooring lines is presented in Table 21. Maximum anchor loads are presented in Table 22. Negative values indicate an upward force at the anchor, whereas positive values indicate a downward force at the anchor.

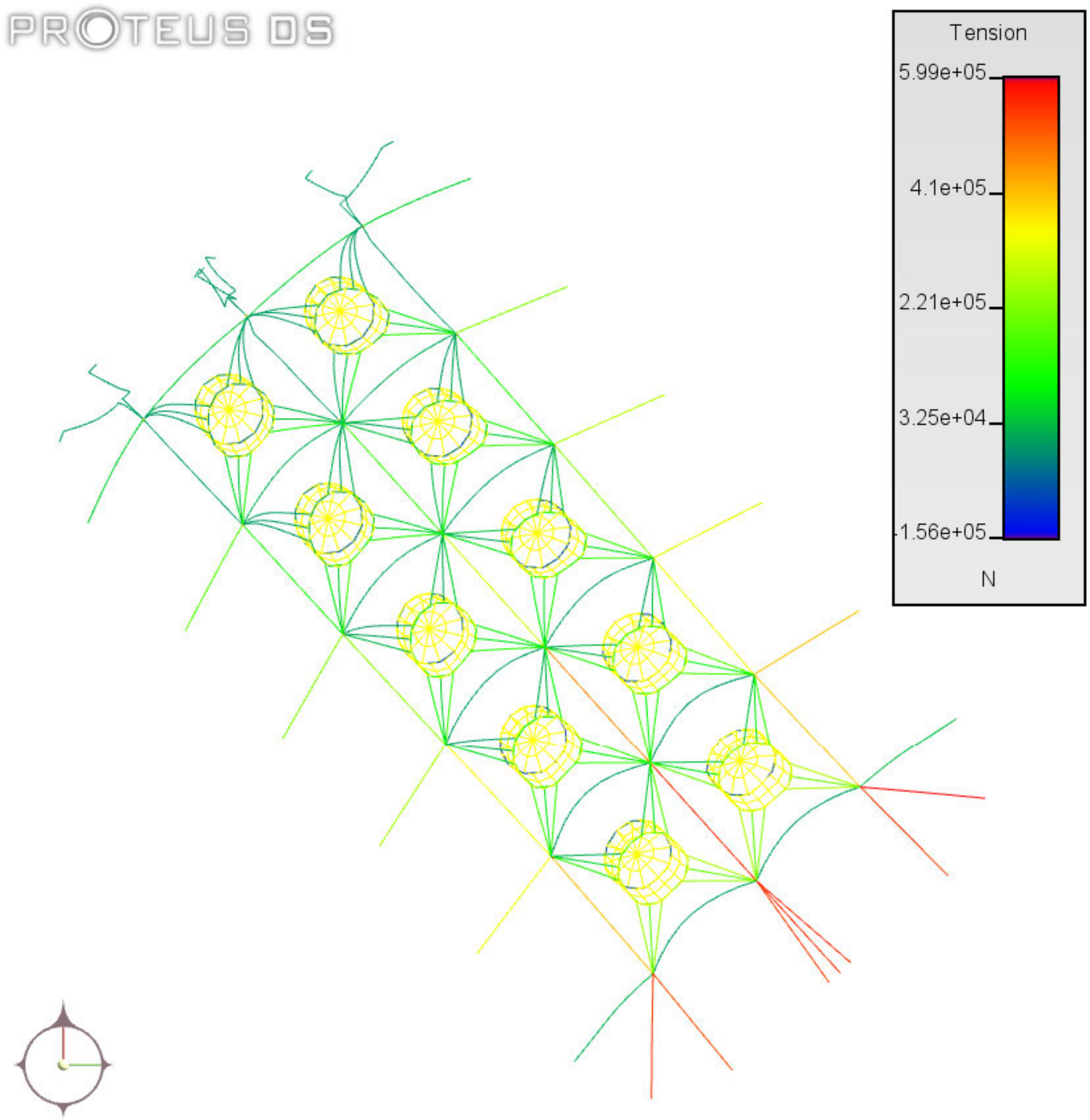


Figure 18. Grid ULS Results – Case ULS 08

Table 21. Grid ULS Results

Component	Simulated Material	Dominant Case	Max tension (kN)	Req'd Safety Factor	Req'd MBL (kN)
West Mooring Lines (2-7)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	368.9	1.67	616.1
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-8	368.4	1.67	615.2
North Mooring Lines (1,19-22)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-4	530.4	1.67	885.8
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-4	530.3	1.67	885.6
East Mooring Lines (13-18)					

Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	425.4	1.67	710.5
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-8	425.0	1.67	709.7
South Mooring Lines (8-12)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	596.6	1.67	996.3
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-8	598.8	1.67	1000.0
Bridle Lines					
Bridle Rope	Axiom Dan-Strong 8 strand 72mm rope	ULS-8	289.8	1.67	484.0
Grid Lines					
Grid Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	569.0	1.67	950.2
Buoy Lines					
Buoy Chain	Sotra Grade 2 studless 24mm mooring chain	ULS-2	42.0	1.67	70.2

Table 22. Grid ULS Anchor Results

Mooring #	Dominant Case	Max horizontal force (tonnes)	Max vertical force (tonnes)
1	ULS-4	51.19	-6.98
2	ULS-8	6.67	0.45
3	ULS-4	33.13	-6.07
4	ULS-9	34.50	-6.48
5	ULS-9	34.69	-6.70
6	ULS-8	36.57	-6.61
7	ULS-4	5.66	0.48
8	ULS-8	55.78	-7.64
9	ULS-8	55.58	-7.30
10A	ULS-8	54.49	-9.10
10B	ULS-8	56.47	-9.47
10C	ULS-8	56.33	-9.43
11	ULS-8	54.48	-7.44
12	ULS-8	60.47	-8.44
13	ULS-15	6.23	0.47
14	ULS-8	42.18	-8.21
15	ULS-15	37.56	-6.69
16	ULS-15	36.66	-6.32
17	ULS-4	34.67	-6.45
18	ULS-15	9.38	0.49
19	ULS-4	53.43	-7.37
20	ULS-4	48.02	-6.53
21A	ULS-4	50.28	-8.33
21B	ULS-4	51.07	-8.48
21C	ULS-4	56.33	-9.43

22	ULS-4	46.35	-6.25

6.3.3 ALS load cases

The accident limit state (ALS) analysis was completed with the load cases described in Table 23. Load case 4 produced the highest loads on the mooring lines, as shown in Figure 19. A summary of the maximum tensions for the mooring lines is presented in Table 24. Maximum anchor loads are presented in Table 25. Negative values indicate an upward force at the anchor, whereas positive values indicate a downward force at the anchor.

Table 23. Grid ALS Load Cases

Load Cases		Heading	Current Speed		Wind Speed (m/s)	Significant Wave Height (m)	Peak wave period (s)	Notes
Case Label	Based on	[to] (deg)	5m	15m				
ALS 01	ULS08	315	1.51	1.57	18.19	2.46	8.50	Break in Grid Line (gridliney4x1)
ALS 02	ULS04	140	1.37	1.32	29.46	2.45	6.03	Break in N Mooring (Mooring 19)
ALS 03	ULS08	315	1.51	1.57	18.19	2.46	8.50	Break in E Mooring (Mooring14)
ALS 04	ULS08	315	1.51	1.57	18.19	2.46	8.50	Break in S Mooring (Mooring12)
ALS 05	ULS08	315	1.51	1.57	18.19	2.46	8.50	Break in W Mooring (Mooring06)
ALS 06	ULS08	315	1.51	1.57	18.19	2.46	8.50	Break in Bridle (cage5x1_bridle4c)
ALS 07	ULS02	45	0.42	0.08	25.44	1.52	3.82	Loss of Buoy (buoyline1x1)
ALS 08	Tsunami	140	1.43	1.43	0	2.6*	N/A**	Tsunami condition; adjusted current and wave height
ALS 09	Tsunami	315	1.43	1.43	0	2.6*	N/A**	Tsunami condition; adjusted current and wave height

* Tsunami wave height given as amplitude (height of crest above mean sea level) not a significant wave height

** Due to uncertainty of wave period, tsunami treated as water elevation change and period is not considered

6.3.4 ALS results

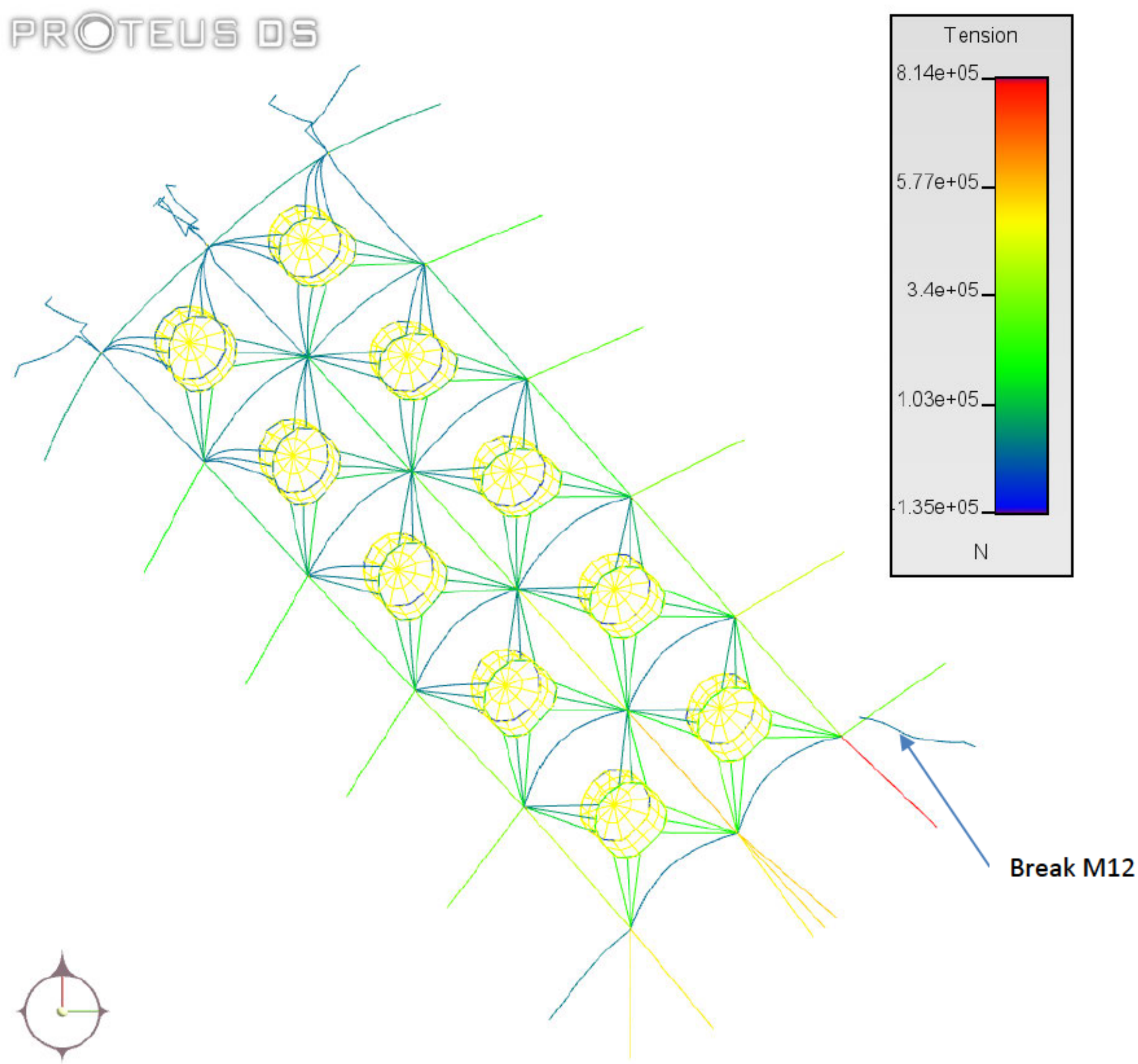


Figure 19. Grid ALS Results - Case ALS 04

Table 24. Grid ALS Results

Component	Simulated Material	Dominant Case	Max tension (kN)	Req'd Safety Factor	Req'd MBL (kN)
West Mooring Lines (2-7)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-1	408.4	1.25	510.5
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-1	407.9	1.25	509.8
North Mooring Lines (1,19-22)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-2	729.7	1.25	912.2

Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-2	729.6	1.25	912.0
East Mooring Lines (13-18)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-1	459.0	1.25	573.7
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-1	459.0	1.25	573.7
South Mooring Lines (8-12)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-4	814.2	1.25	1017.8
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-4	814.0	1.25	1017.6
Bridle Lines					
Bridle Rope	Axiom Dan-Strong 8 strand 72mm rope	ALS-6	394.1	1.25	492.6
Grid Lines					
Grid Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-4	591.0	1.25	738.7
Buoy Lines					
Buoy Chain	Sotra Grade 2 studless 24mm mooring chain	ALS-2	51.8	1.25	64.7

Table 25. Grid ALS Anchor Results

Mooring #	Dominant Case	Max horizontal force (tonnes)	Max vertical force (tonnes)
1	ALS-2	49.10	-7.47
2	ALS-4	6.81	0.46
3	ALS-8	32.19	-7.05
4	ALS-2	24.90	-5.17
5	ALS-5	29.02	-5.02
6	ALS-1	40.47	-7.45
7	ALS-1	5.79	0.48
8	ALS-1	63.35	-8.64
9	ALS-1	56.71	-7.50
10A	ALS-5	53.00	-9.09
10B	ALS-6	56.20	-9.34
10C	ALS-6	57.50	-9.58
11	ALS-4	82.38	-11.62
12	ALS-1	66.89	-9.41
13	ALS-4	31.36	-3.48
14	ALS-1	45.81	-9.21
15	ALS-3	37.19	-7.14
16	ALS-3	30.01	-6.27
17	ALS-2	36.15	-7.95
18	ALS-2	27.27	-2.82
19	ALS-8	50.82	-8.05
20	ALS-2	73.57	-10.39
21A	ALS-2	50.77	-8.92

21B	ALS-2	49.96	-9.11
21C	ALS-2	47.07	-8.88
22	ALS-2	46.41	-6.54

6.3.5 Required MBL and Holding Capacity

Grid system components are specified as per ISO16488 [2] as noted in Table 26 and the attached engineering drawings [9].

Table 26. Grid Component Req'd MBL

Component	Simulated Material	Dominant Case	Max tension (kN)	Req'd Safety Factor	Req'd MBL (kN)
West Mooring Lines (2-7)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	368.9	1.67	616.1
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-8	368.4	1.67	615.2
North Mooring Lines (1,19-22)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-2	729.7	1.25	912.2
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-2	729.6	1.25	912.0
East Mooring Lines (13-18)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	425.4	1.67	710.5
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ULS-8	425.0	1.67	709.7
South Mooring Lines (8-12)					
Mooring Rope	Axiom Dan-Strong 8 strand 80mm rope	ALS-4	814.2	1.25	1017.8
Anchor Chain	Sotra Grade 2 studlink 50mm anchor chain	ALS-4	814.0	1.25	1017.6
Bridle Lines					
Bridle Rope	Axiom Dan-Strong 8 strand 72mm rope	ALS-6	394.1	1.25	492.6
Grid Lines					
Grid Rope	Axiom Dan-Strong 8 strand 80mm rope	ULS-8	569.0	1.67	950.2
Buoy Lines					
Buoy Chain	Sotra Grade 2 studless 24mm mooring chain	ULS-2	42.0	1.67	70.2

Anchor loading listed in Table 22 and Table 25 must apply a load factor of 1.5 and 1.0 for the ULS and ALS cases, respectively. The maximum force with applied load factors for each group of moorings can be found in Table 27.

The maximum required holding capacity of the anchor is 898.4kN. A 1500kg dual shank drag embedment anchor is a suitable anchor, which is expected to have a holding capacity greater than 900kN in sand[10]. Adequate sediment depth is required to ensure effectiveness of the specified anchor. A survey of the anchor locations should be conducted prior to deployment.

Table 27. Req'd Anchor Holding Capacity

Mooring Group	Req'd Holding Capacity (kN)	Req'd Holding Capacity (tonnes)
EAST (moorings 13-18)	631.7	64.39
NORTH (moorings 1,19-22)	793.7	80.90
SOUTH (moorings 8-12)	898.4	91.58
WEST (moorings 2-7)	546.0	55.66

6.3.6 Grid Mooring Summary

In general, the mooring analysis of the fish farm grid indicated that suitable materials are available for mooring the site safely, following safety factors according to ISO 16488 [2, 5] based on realistic estimates of the extreme metocean conditions and suitable load cases applied to the equipment.

The float collar must be designed to resist the loading imposed from the bridle lines. The maximum bridle loads on the floating collars predicted from the simulations were 290kN for the ULS cases, and 394kN for the ALS cases. To verify that a floating collar is available which can meet these loads, the AKVA specifications for their 630mm floating collars at 160m circumference were checked. The load limits were 306kN and 390kN for ULS and ALS, respectively. The allowable loads are very close to the prediction from the simulations, indicating that a floating collar which meets the requirements should be available. However, this element should be reviewed during the detailed design.

As discussed in Section 4.2.3, the 19mm mesh will be used only for a short duration in the production cycle. For the majority of the production cycle, significantly larger mesh will be used, resulting in lower forces throughout the system, including on the bridle lines.

Additionally, Pete Letters of ScaleAQ stated that their floating collars employ a steel tendon system to ensure that the HDPE pipes are not used as a primary structural element for the mooring loads. As such, it could be expected their pen could support this bridle load.

The required anchor holding capacity of 898kN should be achievable with 1500kg dual-shank style anchor in sand [10].

This analysis was done on a representative fish farm grid, based on the maximum net pen depth and metocean conditions. This analysis applied to the entire Hananui Aquaculture Project area. If NTS needs to relocate farms within the Hananui Aquaculture area, the proposed mooring and pen analysis would remain valid. The detailed design will consider the final farm locations within the Hananui Aquaculture Project area.

6.4 Feed barge mooring system model configuration

6.4.1 Mooring layout

The following section describes the design and analysis of the feed barge mooring design, which is shown below in Figure 20. The mooring is a spread 8-point mooring, made up of stud link chain.

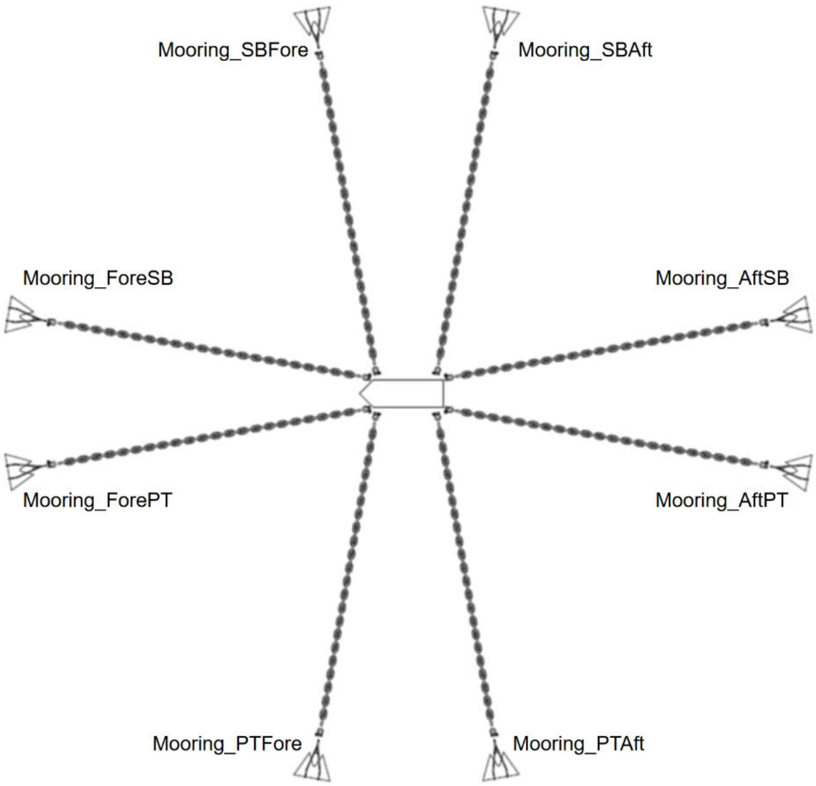


Figure 20. Mooring Layout for Feed Barge (not to scale)

Figure 21 indicates the orientation of the feed barge relative to fish farms on the site. The feed barge's heading is north-west, which is aligned with the direction of the highest frequency of wave occurrence (~320°). This orientation ensures the barge has the highest probability of a head sea during extreme events, which is beneficial for minimizing loading on the barge and connected mooring, and for barge stability. The predominant current flows are also to the northwest and southeast.

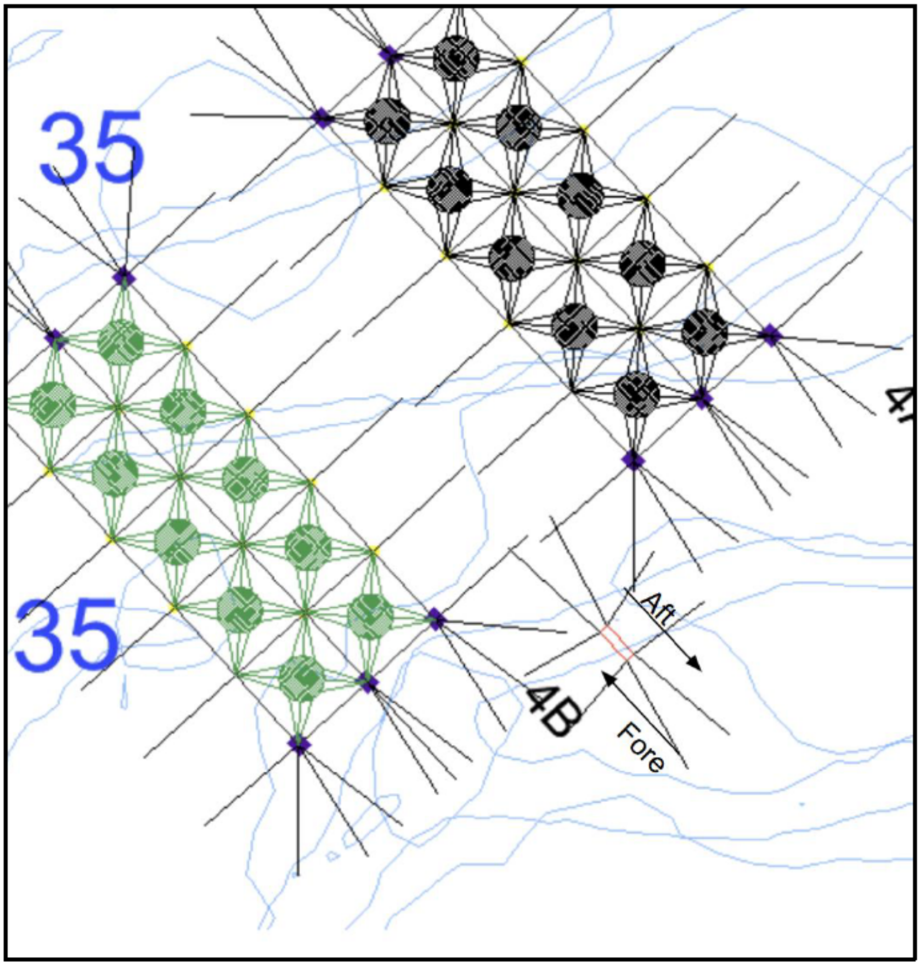


Figure 21. Feed Barge Orientation (heading north-west) relative to farm. Barge and farm are aligned with predominant current direction [to] of 140°, and wave direction [from] 320°

6.4.2 Mooring lines

Details on the configuration of mooring lines are presented in Table 28, as well as materials used for the mooring analysis. Mass per unit length, axial stiffness, MBL, and other properties for each line are listed in Table 29. Substantial deviation from these materials (e.g. size, MBL, rope construction, chain weight) may affect the loads reported by the simulations. **NOTE: These materials are not the finalized specifications, and the MBL requirements in the results section should be adhered to.**

Table 28. Feed Barge Mooring Line Simulation Input

Line	Azimuth (deg)	Chain length (m)	Chain size	Anchor depth (m)
Mooring_AftPT	190	158.5	Studlink 52mm	30
Mooring_AftSB	170	158.5	Studlink 52mm	30
Mooring_ForePT	350	158.5	Studlink 52mm	30

Mooring_ForeSB	10	158.5	Studlink 52mm	30
Mooring_PTAft	260	158.5	Studlink 52mm	30
Mooring_PTFore	280	158.5	Studlink 52mm	30
Mooring_SBAft	100	158.5	Studlink 52mm	30
Mooring_SBFore	80	158.5	Studlink 52mm	30

Table 29. Barge Mooring Material Properties

Mooring materials	Mass in air (kg/m)	Weight in water (kg/m)	EA (N)	MBL (kN)
50mm studlink chain	62.0	53.7	225,963,445	1,480

The mooring pretension at the barge were achieved in simulation under no environmental loading and is presented in Table 30.

Table 30. Feed Barge Mooring Pretensions

Name	Pretension (kN)
Mooring_AftPT	30
Mooring_AftSB	30
Mooring_ForePT	30
Mooring_ForeSB	30
Mooring_PTAft	30
Mooring_PTFore	30
Mooring_SBAft	30
Mooring_SBFore	30

6.4.3 Feed Barge

The feed barge is still under consideration at this stage of design. The initial feed barge model that has been indicated by NTS to be used on-site will be similar as shown in Figure 22. Details of the barge are found in Table 31.

Table 31. Initial Feed Barge Details

Length	40.0 m
Beam	12.0 m
Draft (max)	2.0 m
Depth	3.42 m
Design Displacement	850.0 t
Design Sea State, Hs	6.5 m

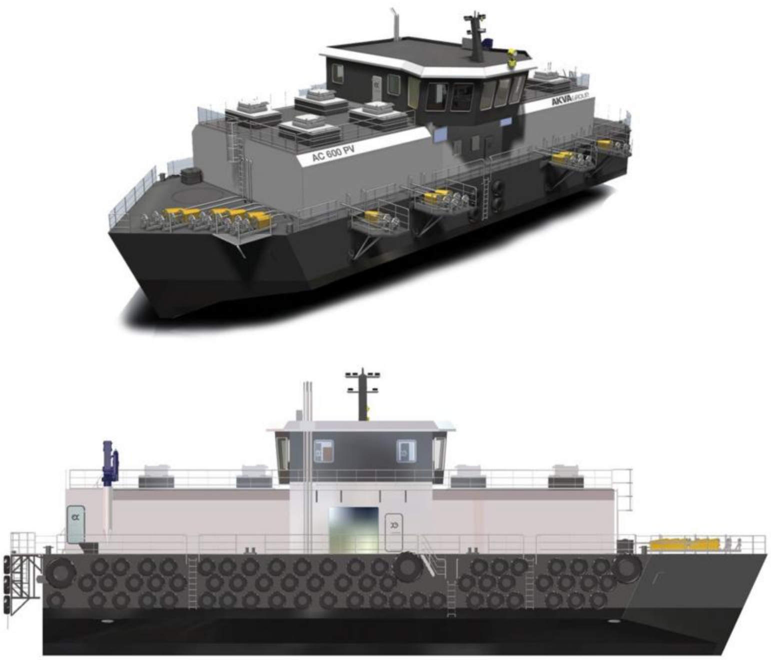


Figure 22. Example Feed Barge (Source: AKVA website)

6.5 Feed barge mooring system analysis results

6.5.1 ULS results

Feed barge simulations were performed using an irregular JONSWAP wave spectrum for a 600 second time period. Wave seeds for simulations were pre-selected based on a pool of 200 wave seeds to produce the highest peak-to-trough wave height occurring at the barge during the 600 second simulation.

The ultimate limit state (ULS) analysis was completed with the load cases described in Section 6.3.1. Load case 12 produced the highest loads on the mooring, as shown in Figure 23.

Simulations were completed for a 600 second duration. It is necessary to extrapolate the tensions to a 3-hour storm duration. Peaks in mooring tension were fit to a Weibull distribution to determine extreme mooring line tensions for a 3-hour storm. It was found that maximum tensions from simulations should be scaled by a factor of 1.19 to represent 3-hour storm conditions.

A summary of the maximum simulation tensions, design tensions, and safety factors for each mooring line is presented in Table 32. Maximum simulation anchor loads, design anchor loads, and safety factors based on expected holding capacity of chosen anchors are presented in Table 33.

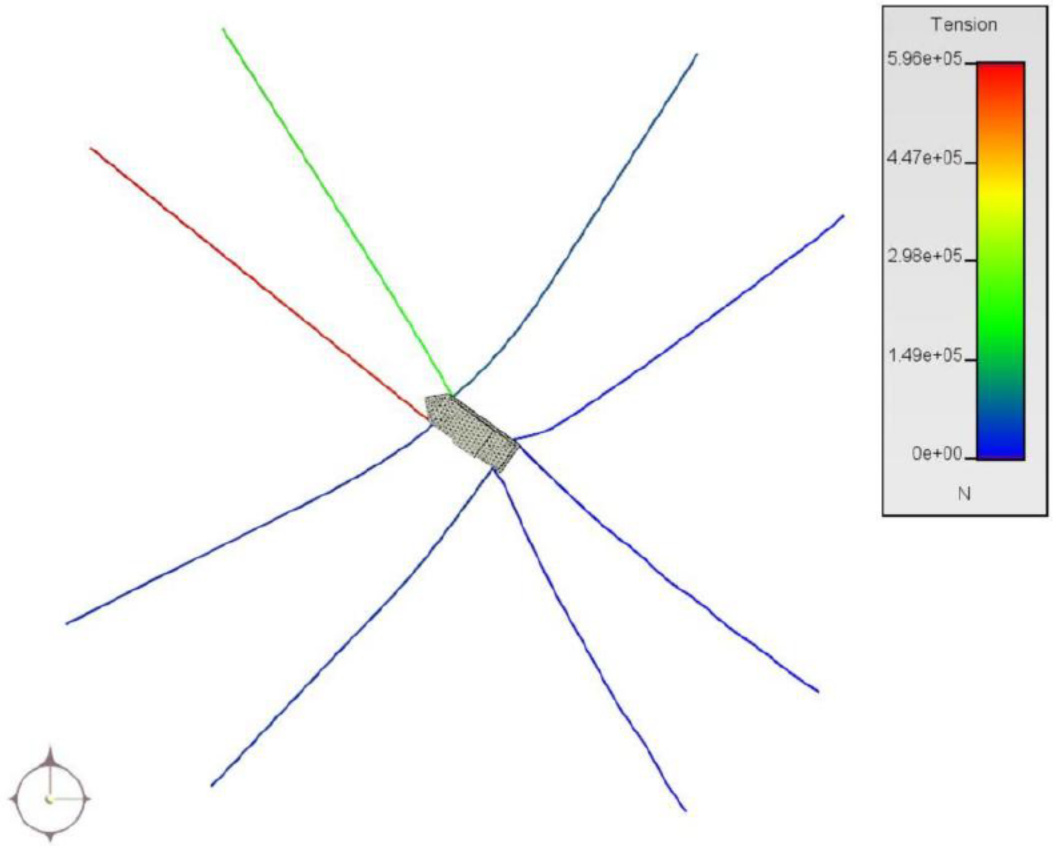


Figure 23. Feed Barge ULS Simulation Case 12

Table 32. Feed Barge ULS Component Results

Line	Material simulated	Case	Max tension (kN)	Design tension (kN)	MBL (kN)	Safety factor	Req'd SF
Mooring_AftPT	52mm studlink chain	16	430	512	1,480	3.44	1.67
Mooring_AftSB	52mm studlink chain	15	586	697	1,480	2.53	1.67
Mooring_ForePT	52mm studlink chain	12	596	709	1,480	2.48	1.67
Mooring_ForeSB	52mm studlink chain	4	278	331	1,480	5.32	1.67
Mooring_PTAft	52mm studlink chain	9	232	276	1,480	6.38	1.67
Mooring_PTFore	52mm studlink chain	9	197	234	1,480	7.51	1.67
Mooring_SBAft	52mm studlink chain	15	423	503	1,480	3.50	1.67
Mooring_SBFore	52mm studlink chain	15	505	601	1,480	2.93	1.67

Table 33. Feed Barge ULS Anchor Results

Line	Case	Max horizontal force (kN)	Max design force (kN)	Holding capacity (kN)	Safety factor	Req'd SF
Mooring_AftPT	16	431.0	512.9	1,060	2.07	1.5
Mooring_AftSB	15	567.6	675.4	1,060	1.57	1.5

Mooring_ForePT	12	594.8	707.8	1,060	1.50	1.5
Mooring_ForeSB	4	278.3	331.2	1,060	3.20	1.5
Mooring_PTAft	15	222.3	264.5	1,060	4.01	1.5
Mooring_PTFore	9	180.2	214.4	1,060	4.94	1.5
Mooring_SBAft	15	364.7	434	1,060	2.44	1.5
Mooring_SBFore	15	488.4	512.9	1,060	2.07	1.5

6.5.2 ALS results

The fore-port mooring line had the highest loading over all ULS simulation cases. All 16 load cases were rerun with the fore-port mooring line broken to produce 16 ALS load cases. Load case 12 produced the highest loads on the mooring for all accident cases, as shown in Figure 24.

Peaks in mooring tension were fit to a Weibull distribution in order to determine extreme mooring line tensions for a 3-hour storm. It was found that maximum tensions from simulations were higher than the extrapolated tensions from the Weibull distribution fit for a 3-hour storm. Therefore, maximum tensions and anchor loads observed in simulation were treated as 3-hour storm design loads.

A summary of the maximum simulation tensions, design tensions, and safety factors for each mooring line is presented in Table 34. Maximum simulation anchor loads, design anchor loads, and safety factors based on expected holding capacity of chosen anchors are presented in Table 35.

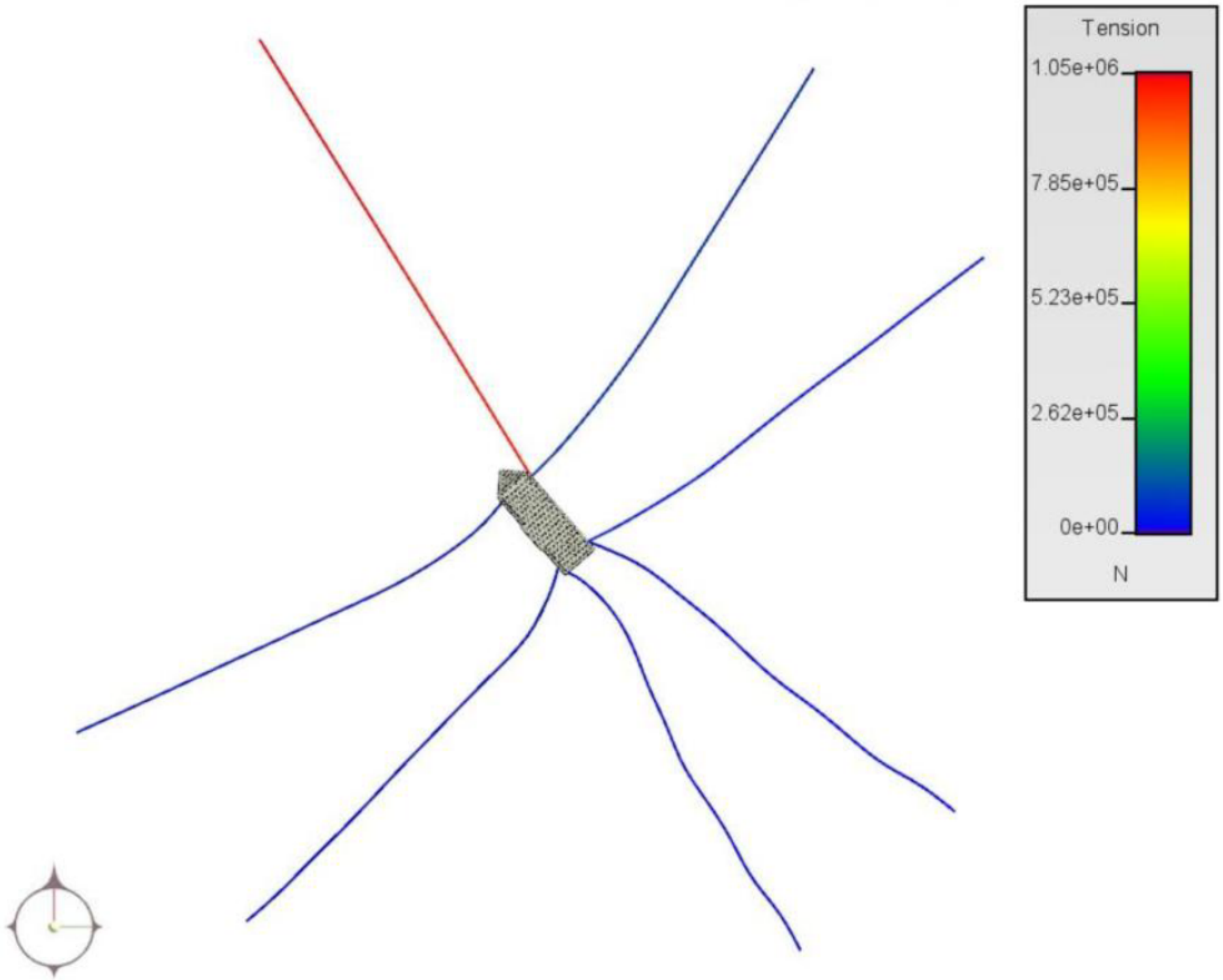


Figure 24. Feed Barge ALS Simulation Case 12

Table 34. Feed Barge ALS Component Results

Line	Material simulated	Case	Max tension (kN)	Design tension (kN)	MBL (kN)	Safety factor	Req'd SF
Mooring_AftPT	52mm studlink chain	16	440	440	1,480	3.36	1.25
Mooring_AftSB	52mm studlink chain	15	553	553	1,480	2.68	1.25
Mooring_ForePT	52mm studlink chain	-	-	-	-	-	-
Mooring_ForeSB	52mm studlink chain	12	1,047	1,047	1,480	1.41	1.25
Mooring_PTAft	52mm studlink chain	9	229	229	1,480	6.46	1.25
Mooring_PTFore	52mm studlink chain	9	221	221	1,480	6.70	1.25
Mooring_SBAft	52mm studlink chain	15	370	370	1,480	4.00	1.25
Mooring_SBFore	52mm studlink chain	15	496	496	1,480	2.98	1.25

Table 35. Feed Barge ALS Anchor Results

Line	Case	Max horizontal force (kN)	Max design force (kN)	Holding capacity (kN)	Safety factor	Req'd SF
Mooring_AftPT	16	440	440	1,060	2.41	1.0
Mooring_AftSB	15	553	553	1,060	1.92	1.0
Mooring_ForePT	-	-	-	-	-	-
Mooring_ForeSB	12	1039	1039	1,060	1.02	1.0
Mooring_PTAft	15	216	216	1,060	4.90	1.0
Mooring_PTFore	9	201	201	1,060	5.28	1.0
Mooring_SBAft	15	336	336	1,060	3.16	1.0
Mooring_SBFore	15	479	479	1,060	2.21	1.0

6.5.3 Required MBL and holding capacity

Based on the feed barge simulations above, the following two components were selected for the concept:

- Feed barge mooring chains
  - 52mm Grade 2 Studlink chain – MBL 1,480 kN
- Feed barge anchors
  - 2500kg dual shank drag embedment anchors – Holding capacity to exceed 1,060kN

7 Concept drawings

Detailed drawings of the mooring concepts were created to support evaluation of the concept. These are provided in Appendix A – Site design drawings.

8 Conclusions

DSA Ocean has completed the front-end engineering design for the proposed Hananui Aquaculture Site to assess the technical feasibility of deploying farm systems off Stewart Island. This work included a comprehensive analysis of metocean conditions, a detailed mooring analysis, and the identification of minimum hardware specifications for mooring and net-pen systems.

Current conditions were characterized using data from three Acoustic Doppler Current Profiler (ADCP) deployments at the site. Wave conditions used in the analyses were predicted using a 38-year hindcast wind and wave model of the surrounding waters. Based on available datasets, the maximum observed current speed was 1.12 m/s; the maximum hourly mean wind speed at 10 m elevation reached 26.62 m/s; and the maximum significant wave height was 3.48 m. The estimated 1-in-50-year return period conditions were: a peak current speed of 1.568 m/s, wind speed of 29.46 m/s, and significant wave height of 3.48 m.

The seabed within the lease area is primarily sandy, providing suitable conditions for anchoring with drag embedment anchors. Each block of ten pens is arranged on a submerged mooring grid (110 m × 110 m spacing) set at a depth of 6 m. Net pens are secured within the center of each grid cell using bridle lines and consist of standard HDPE circular floating collars with a circumference of 168 m, to which the net enclosures are attached.

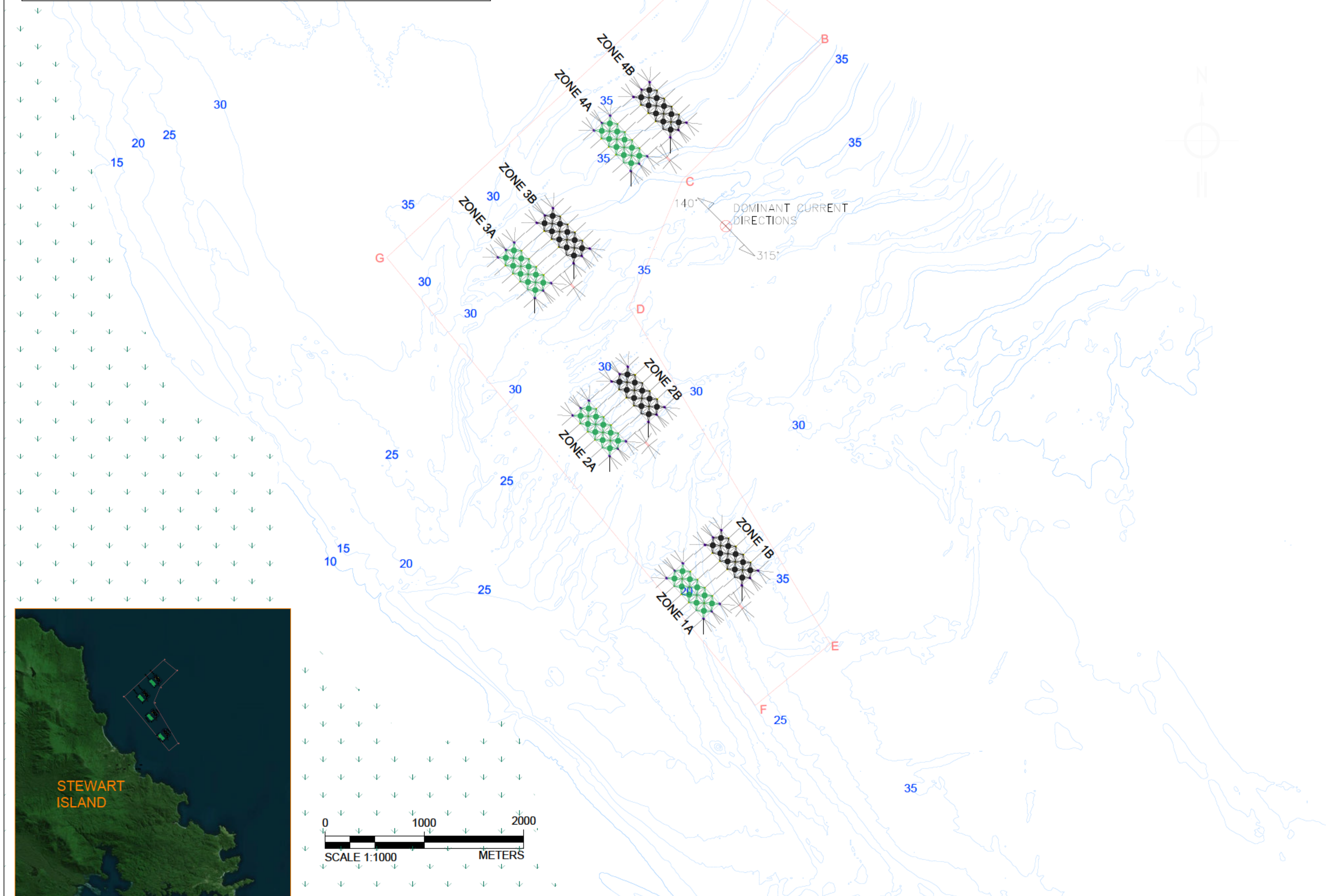
Each grid will be serviced by an adjacent feed barge equipped with automated feeding systems to ensure consistent fish feeding even in adverse weather.

To evaluate mooring feasibility and support the conceptual farm design, dynamic mooring analyses were conducted. These analyses considered load cases based on 1-in-10 and 1-in-50-year extreme conditions, and assessed the resulting forces on all mooring components. Single-wall net pen enclosures based on the smallest mesh opening considered (19mm) was evaluated. High-strength HDPE netting was selected for its durability and its ability to limit interactions with marine mammals and seabirds.

The results confirmed that a single configuration is technically viable at the Hananui site, with final technology selection to be determined during detailed engineering. Overall, this study demonstrates the engineering feasibility of the Hananui Aquaculture Project using proven equipment from leading industry suppliers. This report forms the foundation for the detailed design and final specification of the farm systems.

9 Appendix A – Site design drawings

NOTE: CONCEPT SITE PLAN BASED ON ANALYSIS OF PROPOSED GROW-OUT PEN SYSTEMS. SEE NOTES IN TITLE BLOCK FOR ADDITIONAL INFORMATION.



NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

SITE ARRANGEMENT

FARM FEATURES	ENVIRONMENT FEATURES
MOORING LINE	SHORELINE
BUOY 6600L	BATHYMETRY
BUOY 2200L	LAND
NET PEN PHASE 1	DOMINANT CURRENT DIR
NET PEN PHASE 2	LEASE BOUNDARY
GRID CELL	ADCP LOCATION DEC 2018
FEED BARGE	

LEASE CORNER COORDINATES

A	46°43'50.69"S 168° 3'58.60"E
B	46°44'21.00"S 168° 4'48.83"E
C	46°45' 3.65"S 168° 3'40.66"E
D	46°45'44.51"S 168° 3'13.27"E
E	46°47'36.70"S 168° 4'42.66"E
F	46°47'55.76"S 168° 4' 6.08"E
G	46°45'25.28"S 168° 1'19.09"E

NOTES:

1) PREDOMINANT CURRENT DIRECTIONS AT ADCP LOCATION
2) BATHYMETRY BASED ON MULTIBEAM DATA PROVIDED BY CAWTHRON INSTITUTE
3) ESTIMATED MAXIMUM 1 IN 50 YEAR WAVE CONDITION. Hs=3.48M
4) ESTIMATED MAXIMUM ANNUAL CURRENT AT 5M DEPTH: 1.17 M/S
5) ESTIMATED 1 IN 50 YEAR RETURN PERIOD WIND SPEED: 29.46 M/S
6) COMPONENTS SPECIFIED ACCORDING TO ISO16488.

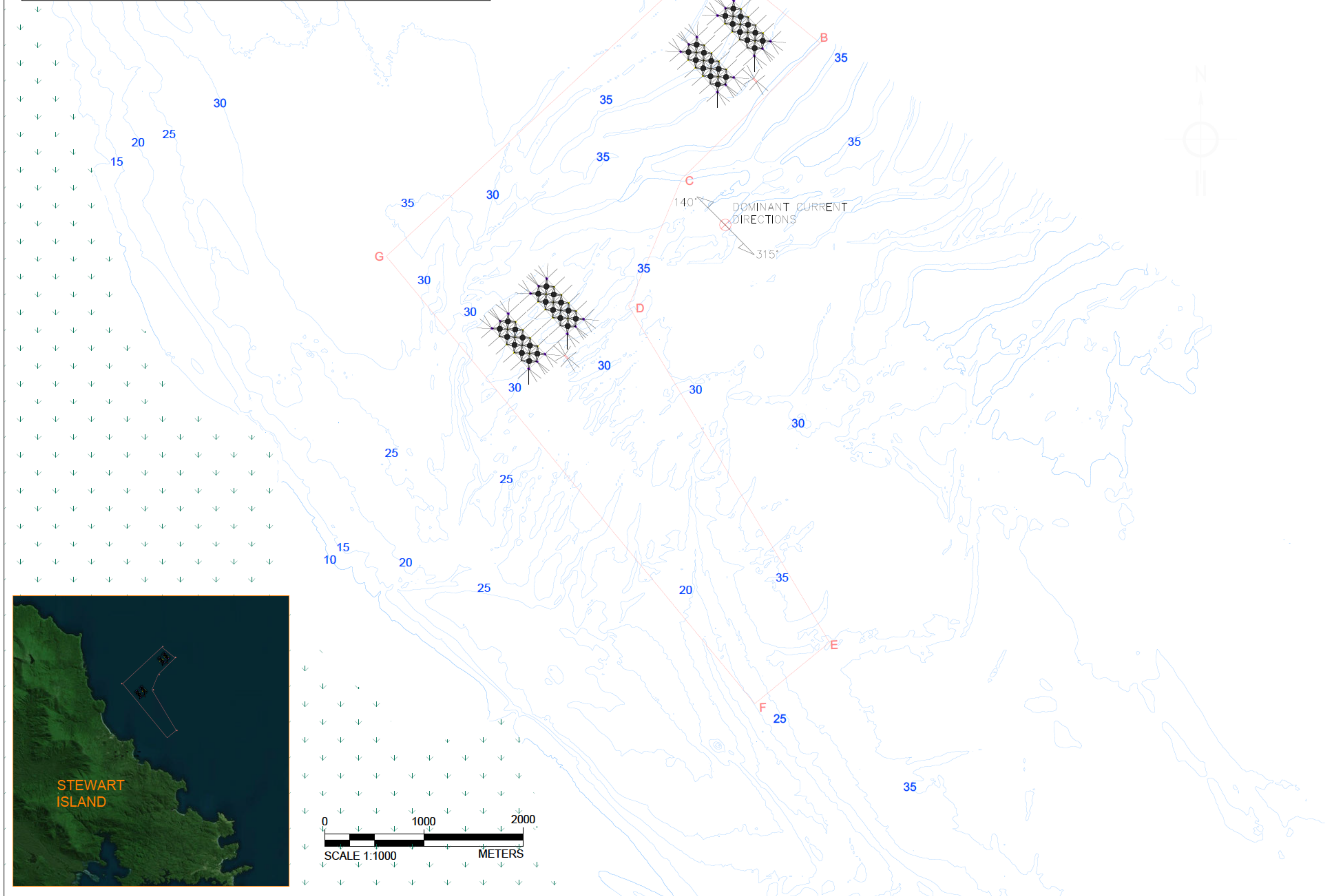
DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 1 OF 8

DRAWN BY: RB
CHECKED BY: CJW
APPROVED BY: CJW
LAST REVISED: 2025-11-05
REVISION: D

NOTE: CONCEPT SITE PLAN BASED ON ANALYSIS OF PROPOSED GROW-OUT PEN SYSTEMS. SEE NOTES IN TITLE BLOCK FOR ADDITIONAL INFORMATION.



NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

SITE ARRANGEMENT
ALTERNATIVE FARM POSITIONS

FARM FEATURES	ENVIRONMENT FEATURES
MOORING LINE	SHORELINE
BUOY 6600L	BATHYMETRY
BUOY 2200L	LAND
NET PEN PHASE 1	DOMINANT CURRENT DIR
GRID CELL	LEASE BOUNDARY
FEED BARGE	ADCP LOCATION DEC 2018

LEASE CORNER COORDINATES

A	46°43'50.69"S 168° 3'58.60"E
B	46°44'21.00"S 168° 4'48.83"E
C	46°45' 3.65"S 168° 3'40.66"E
D	46°45'44.51"S 168° 3'13.27"E
E	46°47'36.70"S 168° 4'42.66"E
F	46°47'55.76"S 168° 4' 6.08"E
G	46°45'25.28"S 168° 1'19.09"E

NOTES:

1) PREDOMINANT CURRENT DIRECTIONS AT ADCP LOCATION
2) BATHYMETRY BASED ON MULTIBEAM DATA PROVIDED BY CAWTHRON INSTITUTE
3) ESTIMATED MAXIMUM 1 IN 50 YEAR WAVE CONDITION. Hs=3.48M
4) ESTIMATED MAXIMUM ANNUAL CURRENT AT 5M DEPTH: 1.17 M/S
5) ESTIMATED 1 IN 50 YEAR RETURN PERIOD WIND SPEED: 29.46 M/S
6) COMPONENTS SPECIFIED ACCORDING TO ISO16488.

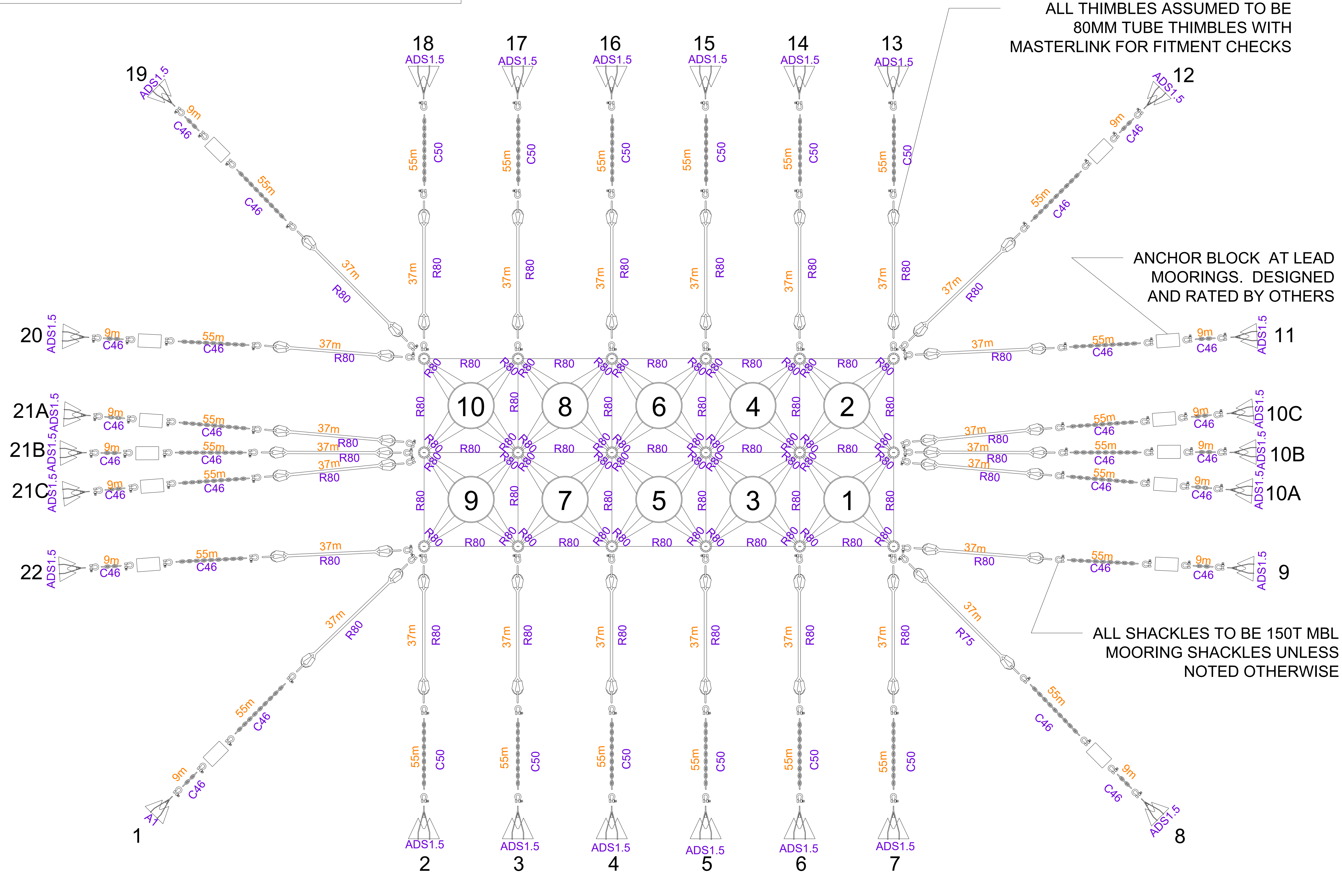
DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 2 OF 8

DRAWN BY:	RB		
CHECKED BY:	CJW	LAST REVISED:	2025-11-05
APPROVED BY:	CJW	REVISION:	D

NOTE: CONCEPT MOORING DESIGN FOR PENS IN ZONES 1-4. SEE NOTES IN TITLE BLOCK FOR ADDITIONAL INFORMATION.



NOT TO SCALE

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

GRID HARDWARE

FEATURES

R80	80MM CO-POLYMER 8 STRAND MIN MBL = 1018kN
C46	46MM G2 STUDLINK CHAIN MBL = 1170kN
ADS1.5	DS ANCHOR 1500KG

NOTES:

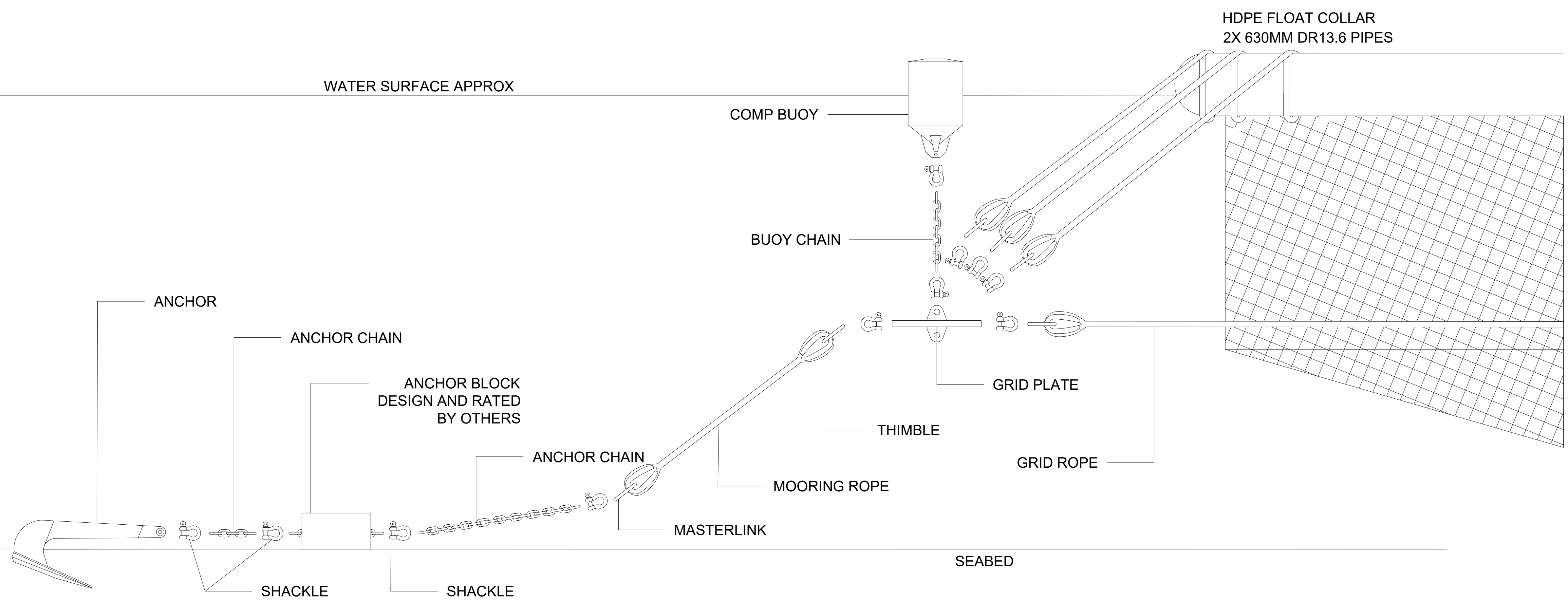
1) ROPE, CHAIN, SHACKLES AND ANCHOR REQUIREMENTS HAVE BEEN ASSESSED USING ISO16488. ANALYSIS IS DOCUMENTED IN DSA-NGAI-25FEED-R01-HANANUI AQUACUTURE SITE-FRONT END ENGINEERING DESIGN REPORT
2) ANCHOR BLOCK TYPICAL ON MOORINGS M01, M08-M12 AND M19-M22
4) ESTIMATED MAXIMUM 1 IN 50 YEAR WAVE CONDITION. Hs=3.48M
5) ESTIMATED MAXIMUM ANNUAL CURRENT AT 5M DEPTH: 1.17 M/S
6) ESTIMATED 1 IN 50 YEAR RETURN PERIOD WIND SPEED: 29.46 M/S

DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 3 OF 8

DRAWN BY:	RB		
CHECKED BY:	CJW	LAST REVISED:	2025-11-05
APPROVED BY:	CJW	REVISION:	D



NOT TO SCALE

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

LEAD MOORING ANCHORING ELEVATION

NOTES:

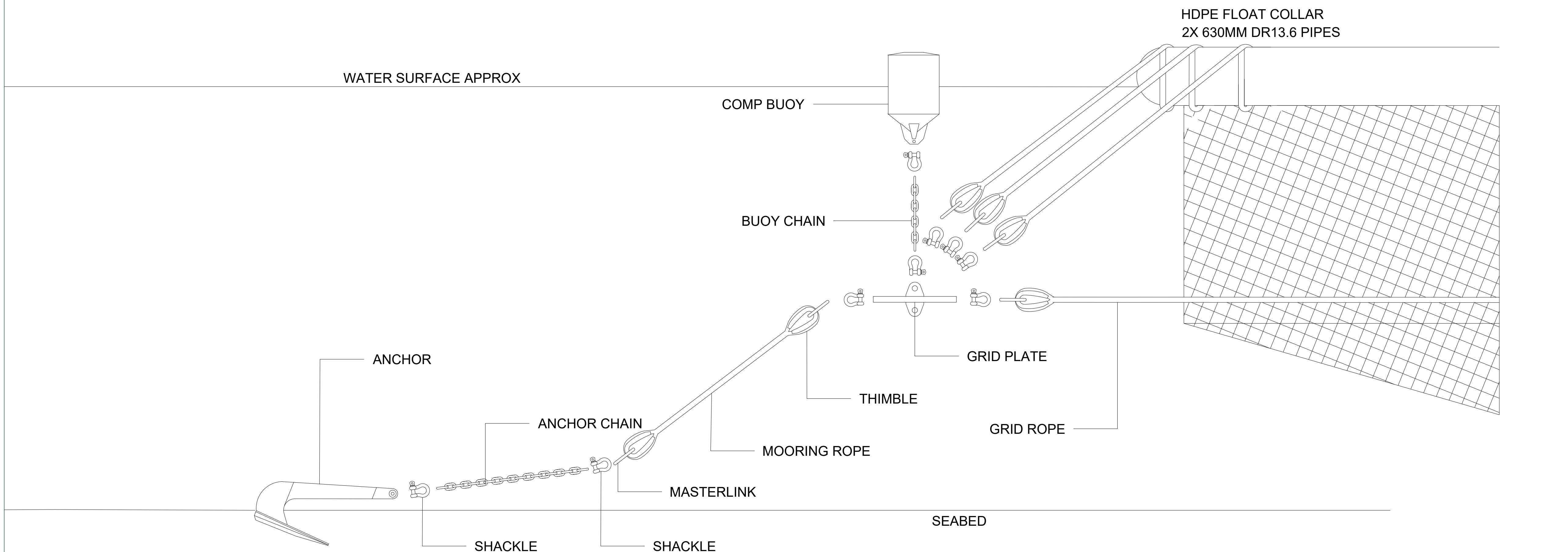
1) LEAD MOORINGS PROVIDE SYSTEM STABILITY UNDER PREDOMINANT CURRENT DIRECTIONS.
2) ANCHORING ELEVATION APPLICABLE TO LEAD MOORINGS M01, M08-M12 AND M19- 22
3) SEE SHEET 3 "GRID HARDWARE" FOR COMPONENT SPECIFICATIONS AND LEAD MOORING LOCATIONS.

DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 4 OF 8

DRAWN BY:	RB		
CHECKED BY:	CJW	LAST REVISED:	2025-11-05
APPROVED BY:	CJW	REVISION:	D



NOT TO SCALE

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

NON-LEAD MOORING ANCHORING ELEVATION

NOTES:

1) LEAD MOORINGS PROVIDE SYSTEM STABILITY UNDER PREDOMINANT CURRENT DIRECTIONS. ALL OTHER MOORINGS ARE NON-LEAD.
2) ANCHORING ELEVATION APPLICABLE TO NON-LEAD MOORINGS M02-M07 AND M13-M18
3) SEE SHEET 3 "GRID HARDWARE" FOR COMPONENT SPECIFICATIONS AND LEAD/ NON-LEAD MOORING LOCATIONS.

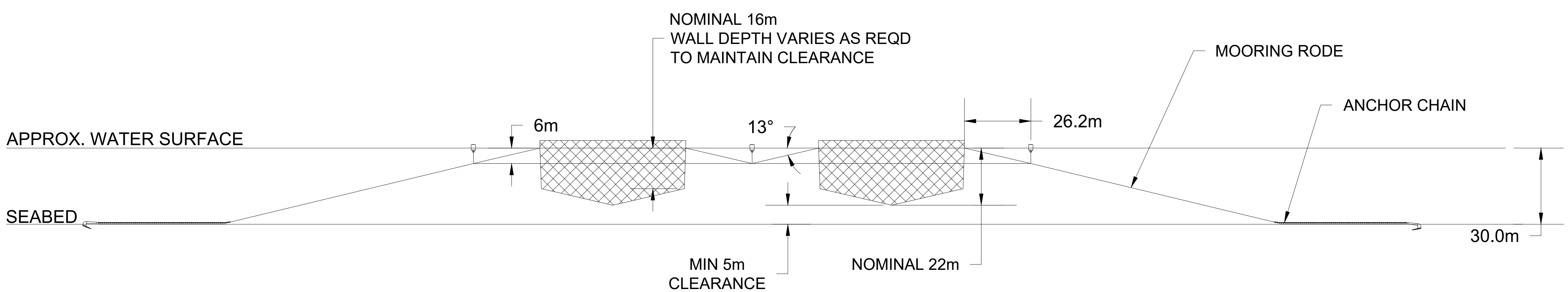
DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 5 OF 8

DRAWN BY: RB
CHECKED BY: CJW LAST REVISED: 2025-11-05
APPROVED BY: CJW REVISION: D

NOTE: CONCEPT MOORING DESIGN ELEVATION FOR NAVIGATION PURPOSES. SEE NOTES IN TITLE BLOCK FOR MORE INFORMATION.



SEABED DEPTH RANGES FROM 20M TO 30M ACROSS THE PROPOSED LEASE AREA. 5M CLEARANCE FROM THE SEABED TO THE LOWEST POINT OF THE NET PEN WILL BE MAINTAINED. NET PEN WALL DEPTH WILL VARY TO PROVIDE SUFFICIENT CLEARANCE.

0 50 100

SCALE 1:50 METERS

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

GROW-OUT CAGE NAVIGATION ELEVATION

NOTES:

1) GROW-OUT SYSTEM ELEVATION FOR NAVIGATION PURPOSES
2) SYSTEM SHOWN AT LOW TIDE

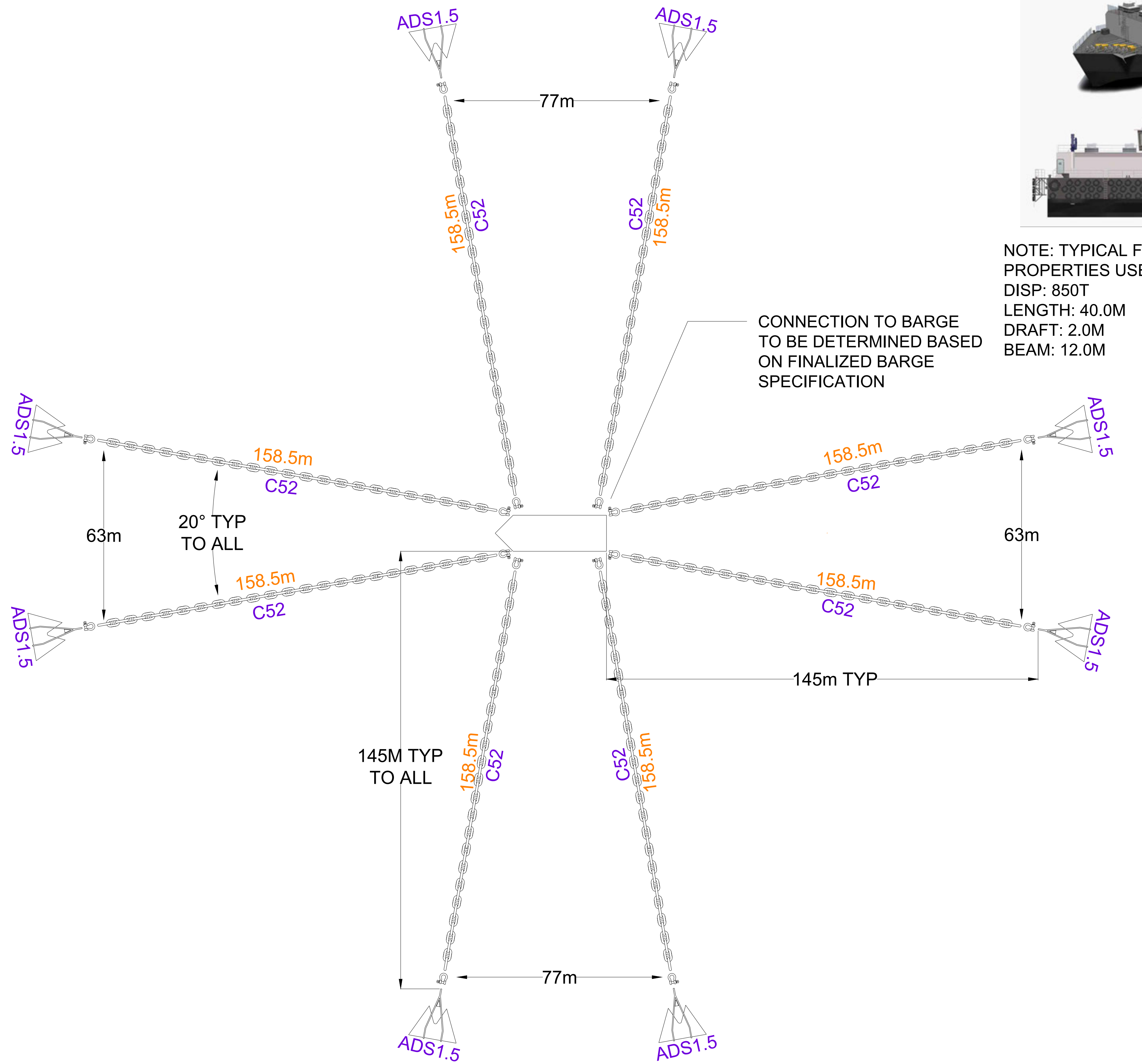
DSAocean

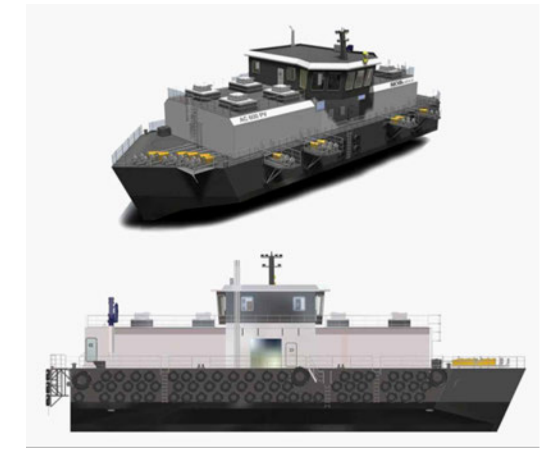
DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 6 OF 8

DRAWN BY:	RB		
CHECKED BY:	CJW	LAST REVISED:	2025-11-05
APPROVED BY:	CJW	REVISION:	D

NOTE: CONCEPT MOORING DESIGN FOR ALL FEED BARGES. SEE NOTES IN TITLE BLOCK FOR ADDITIONAL INFORMATION.





NOTE: TYPICAL FEED BARGE PROPERTIES USED FOR DESIGN
DISP: 850T
LENGTH: 40.0M
DRAFT: 2.0M
BEAM: 12.0M

NOT TO SCALE

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

FEED BARGE HARDWARE

FEATURES

C52	52MM GRADE 2 STUDLINK CHAIN MBL = 1480 kN
ADS1.5	DS ANCHOR 2500KG

NOTES:

1) ROPE, CHAIN, SHACKLES AND ANCHOR REQUIREMENTS HAVE BEEN ASSESSED USING ISO16488. ANALYSIS IS DOCUMENTED IN DSA-NGAI-25FEED-R01-HANANUI AQUACULTURE SITE-FRONT END ENGINEERING REPORT
4) ESTIMATED MAXIMUM 1 IN 50 YEAR WAVE CONDITION. Hs=3.48M
5) ESTIMATED MAXIMUM ANNUAL CURRENT AT 5M DEPTH: 1.17 M/S
6) ESTIMATED 1 IN 50 YEAR RETURN PERIOD WIND SPEED: 29.46 M/S

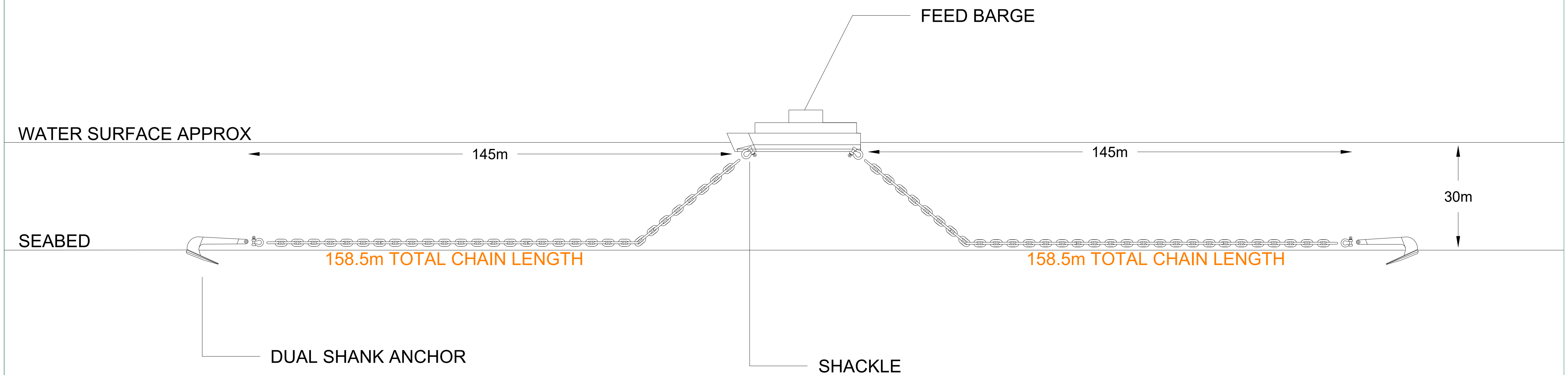
DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 7 OF 8

DRAWN BY: RB
CHECKED BY: CJW LAST REVISED: 2025-11-05
APPROVED BY: CJW REVISION: D

NOTE: TYPICAL FEED BARGE
PROPERTIES USED FOR DESIGN
DISP: 850T
LENGTH: 40.0M
DRAFT: 2.0M
BEAM: 12.0M



NOT TO SCALE

NGĀI TAHU SEAFOOD

HANANUI AQUACULTURE SITE
STEWART ISLAND,FOVEAUX STRAIGHT, NZ

FEED BARGE ANCHORING ELEVATION

NOTES:

1) SEE DRAWING "FEED BARGE HARDWARE" FOR COMPONENT SPECIFICATIONS

DSAocean

DRAWING NUMBER: DSA-NGAI-25FEED-REVD

SHEET 8 OF 8

DRAWN BY:	RB		
CHECKED BY:	CJW	LAST REVISED:	2025-11-05
APPROVED BY:	CJW	REVISION:	D