



Aqualine Midgard Sea-Cage Study

**Component Study for the
Environmental Impact Statement of the
Placentia Bay Atlantic Salmon Aquaculture Project**

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1.0 Component Study - Aqualine Midgard System

This study was carried out by the following independent panel of experts:

- **DNV GL**
 - Richard Kennedy
 - Keith Downey
- **Spence Corrosion Canada Inc.**
 - Gerry Sullivan
 - Norm Spence
- **Engineered Pipe Group**
 - Steve Fleming
 - Anthony Parker
 - Brian Parker
- **AKVA Group North America**
 - Keith Richford
- **Independent Reviewer**
 - Jamie Norris

The independent panel of experts has advised that they will utilize internal and external resources both locally and internationally which they feel are needed for complementing the component study. These external resources will be used for documentation purposes only. For a full description of the independent panel of experts see Appendix I.

1.1 Rationale/Objectives

This document is the Aqualine Midgard Sea-Cage Component Study as required in the Environmental Impact Statement (EIS) Guidelines for the Placentia Bay Atlantic Salmon Aquaculture Project proposed by Grieg NL (Grieg NL; NL Department of Municipal Affairs and Environment 2018). Floating fish farming installations are complex structures that include a large number of components for floating collars, moorings, nets and other accessories. Hence, experience and knowledge on design, operation and risk assessment is very important to understand concepts and make designs with highest reliability.

Aqualine has delivered equipment to the fish farming industry in the toughest and most demanding oceans in the world for more than 35 years. The Aqualine design focuses on robust solutions and concepts that integrate floating collars, mooring and nets into one system. This philosophy is based on engineering research and evaluations, such as extensive work at the model basin at Marintek (<https://www.sintef.no/en/marintek/about-marintek/>) Trondheim. Aqualine ensure customers a redundant structural design with respect to the following design criteria:

1. Serviceability Limit State
2. Ultimate Limit State
3. Accidental Limit State
4. Fatigue Limit Stage

The following sections discuss the existing information and certifications complied by Aqualine indicating the success, qualifications, and standards employed when designing and deploying the Midgard system.

1.2 Study Area

The boundaries of the Study Area have been defined as the Placentia Bay Extension Ecologically and Biologically Sensitive Area (EBSA) (DFO 2012) (Figure 1)). Within the study Area, the focus of this component study is on the Aqualine Midgard System that will be used in the proposed sites located in the Bay Management Areas (BMAs).

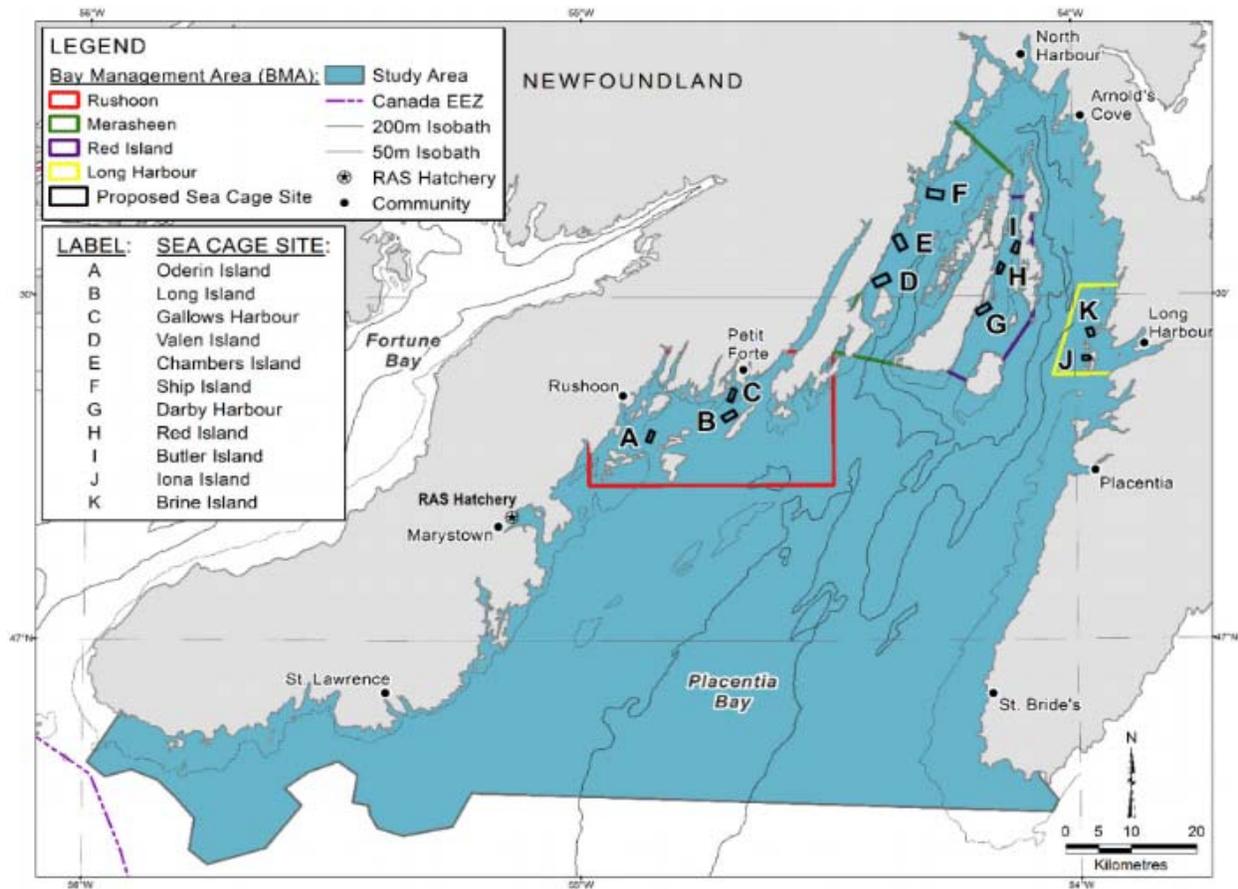


Figure 1. The Study Area, Bay Management Areas, and proposed sea cage sites for Grieg NL's Placentia Bay Atlantic Salmon Aquaculture Project.

1.3 Methodology

This component study is essentially a literature review of information and certifications on the following topics as required in the Final Guidelines for the EIS:

- *A description of the proposed Aqualine Midgard System, which has been designed against a Norwegian technical standard that has been viewed as effective at reducing escape incident rates in other jurisdictions.*
- *A summary of the successes, failures, and lessons learned from Midgard cage system installations at marine aquaculture sites in northern environments.*
- *Methods and results of structural and operational tests conducted for, or collected by, the panel of experts on the Midgard cage system, and a synopsis of test results and conclusions for any previous structural and operational tests conducted on the cage system;*
- *The application of oceanographic and meteorological data, including past sea-ice events, to predict the performance of the sea cages in the study area*
- *Evaluation of the Norwegian technical standard in comparison to current containment practices and standards in Newfoundland and Labrador, with a view to confirming the integrity of the proposed system in the Newfoundland and Labrador marine environment.*

This component study has been completed based on available documents and willingness from the various providers of components to share commercially sensitive information.

1.4 Study Outputs

The Aqualine Midgard System which is being utilized in the Placentia Bay Atlantic Salmon Aquaculture Project is proposed to be reviewed as components for the ring (floating collar). However, it is important to look at this as a system as a whole (floating collar, net, and mooring system). Focus must be given to how the components are interconnected to create the system being proposed.

The following sections discuss the various Aqualine Midgard System related topics listed in Section 1.3 Methodology.

1.4.1 Overview of Aqualine Midgard System

NS 9415:2009 (Appendix II) is a governing technical Standard for floating fish farming installations. NS 9415 is based on extensive work from Norwegian Authorities as well as research and key vendors in the industry. This Standard gives recommendations and regulations on important aspects as:

- Material Specifications
- Design Approach with respect to analyses methods and testing
- Material and Load factors for Serviceability Limit State (SLS), Ultimate Limit State (ULS) and Accidental Limit State (ALS). Fatigue Limit State (FLS) is also specified.
- Net Specifications
- Environmental Specifications

The design approach achieved by applying NS 9415 results in systems with high reliability and good integrity. Furthermore, extensive in-house experience at Aqualine also contributes to even higher reliability on the installations. Below is a description of the proposed Aqualine Midgard system, which has been designed against the Norwegian Technical Standard NS 9415 and has been viewed as effective at reducing escape incident rates in other jurisdictions as described in Section 1.4.2 Summary of Successes, Failures, and Lessons Learned (see Figures 12, 13, and 14).

The sea cage system Grieg NL proposes to use in the Placentia Bay Atlantic Salmon Aquaculture Project is the advanced heavy-duty Aqualine Midgard System (designed by Aqualine AS in Norway). The Aqualine Midgard System has been designed, modelled and tested both in marine laboratories and in the field (Section 1.4.2). There are currently over 1000 of these systems in use in locations such as northern Norway, Iceland and the Faroe Islands. These locations are harsh and cold environments similar to Placentia Bay but with waves and currents higher than recorded in Placentia Bay (Section 1.4.4). Each of the locations that an Aqualine Midgard System is in use, follow strict aquaculture policies and documentation that requires any fish escapes to be reported to authorities and documented. To date there have been no reported fish escapes during production of 350 million fish (~2 million tons) in locations using the Aqualine Midgard system (Section 1.4.2.2). Each sea cage will consist of the following primary components: cage net, floating collar, gangway, sinker ring (tube), winches, and Mortex system (Figure 2). Additionally, for mitigative purposes sea cages will be equipped where appropriate with anti-bird netting, sea lice skirts, a sub-sea feeding apparatus and will be attended by an ROV and operator as well as camera monitoring above and below the surface.

Aqualine began the development process by sending experts from their offices in Norway to Newfoundland and Labrador. In cooperation with the client, field trips to all sites were conducted and information gathered. In addition to scientific data, locals were also consulted on site locations and any possible issues within these areas. From 2015-2018, several site visits were conducted

with the client to verify all information and finetune specific design. Procedures for assembling locally and verification of all steps are guided by NS 9415 and Spence Corrosion Canada.

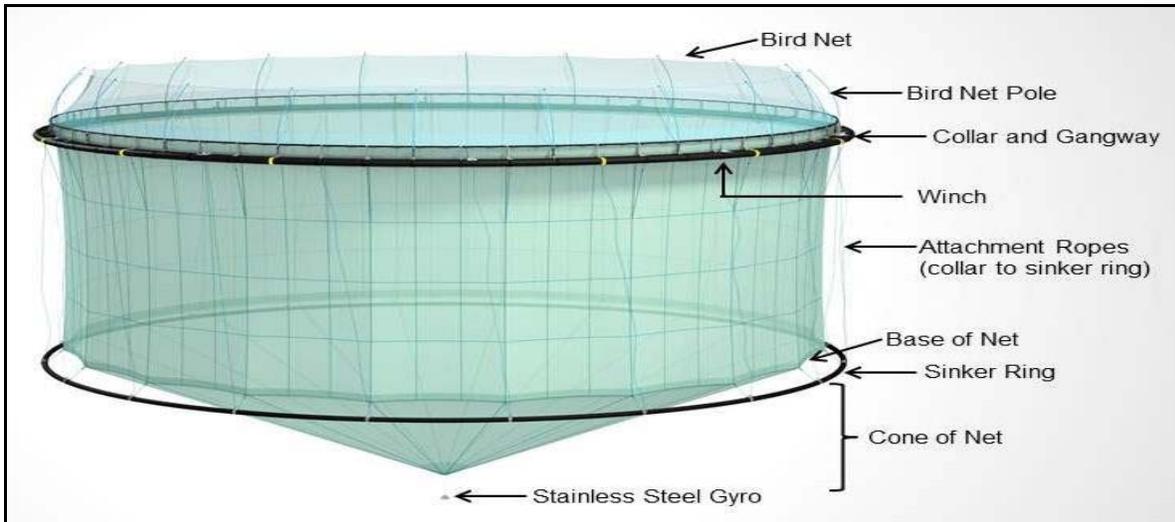


Figure 2. Aqualine Midgard System. Schematic showing the sea cage system proposed by Grieg NL (Aqualine Midgard System).

1.4.1.1 Description of the Aqualine Midgard System.

The net will have a length of 46.5 m, extending 45 m below the water surface, and have a dry weight of 3116 kg. Each sea cage will hold approximately 160,000 fish, weigh roughly 35 tons, certified by DNV GL and has been subjected to simulation tests by SINTEF. The netting is made of black ultra-violet (UV) stabilized material (i.e., Aqualine Ultima/Ultra SG netting which is made with high-density polyethylene (HDPE) material). The mesh size from knot to knot is 17.5 mm².

The netting is affixed to attachment ropes on the outside of the net and it is drawn into an apex at the bottom and affixed to a stainless-steel gyro (Figure 2). By fastening the net onto brackets, an even distribution of the net load into the system is ensured. The cone-shaped net which extends approximately 13 m below the base of the net, will allow fish to descend deeper into the net without increasing the stocking density (i.e., number of fish/volume of the cage).

A common method employed on sea cage systems to control predation is the use of a physical barrier to protect the farmed fish from airborne predators. The Midgard System has a dedicated predator net system. In their proposal, Grieg NL intends to utilize a bird net on all its cages. The bird net and bird poles (Figures 3 and 4) provides sufficient tension to eliminate sagging; this minimizes predation on the fish by birds and reduces the interface of the netting when fish are feeding. The sides of the bird net can be raised and lowered like a window blind to quickly and easily access the cage. The bird net extends 5.9 m above the surface of the water.



Figure 3. Bird net. Bird net and poles to be used as predator control on the sea cages.



Figure 4. Bird net poles.

The floating collar surrounds the net and consists of two floating rings with a gangway (Figure 5), equipped with anti-slip construction and handrails, between to allow for safe manoeuvring around the sea cage. The gangway is mounted to a set of small pipes around the circumference of the cage. The main supporting system consists of steel/plastic brackets connected to steel rods, chains, and fiber ropes which handles the forces around the circumference of the floating collar. Bushings between the steel brackets and floater tubes reduce friction and the floater tubes can move freely inside the brackets (rotation and longitudinal). The loads from the mooring system are distributed around the circumference of the net and are handled by separate steel mooring brackets (Figure 5). There is expanded polystyrene in both floater tubes to maintain the buoyancy in case of any damage or puncture.

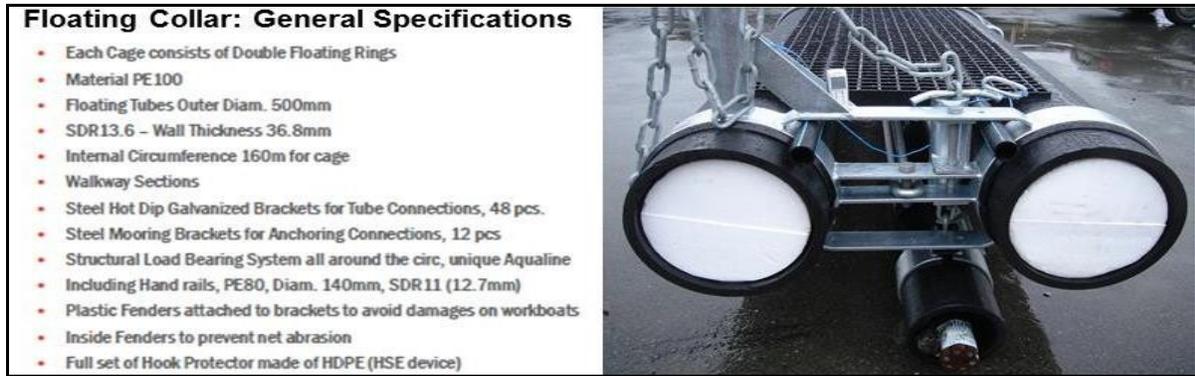


Figure 5. Floating Collar. Specifications and photo of a floating collar showing floating rings and gangway.

The sinker ring (Figure 6) hangs directly from the net with a series of 20 suspension ropes extending approximately 2 m below the base of the net while the cone (see Figure 2) extends another 15 m below. The cage is secured with crows feet anchoring. Crows feet are an arrangement of ropes that allow one main rope to exert pull at several points simultaneously through a group of smaller ropes (Figure 7). Integrating the net and sinker ring provides optimum net tensioning and fish rearing capacity. The sinker tube is constructed of polyethylene plastic, has a diameter of 40 cm, and a submerged weight of ~60 kg/m.

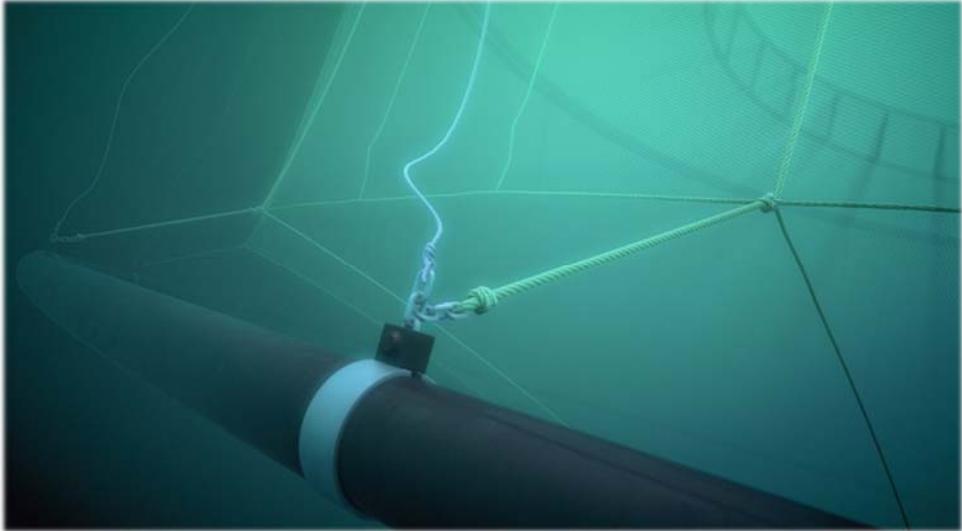


Figure 6. Aqualine’s Midgard System with sinker ring, suspension ropes.

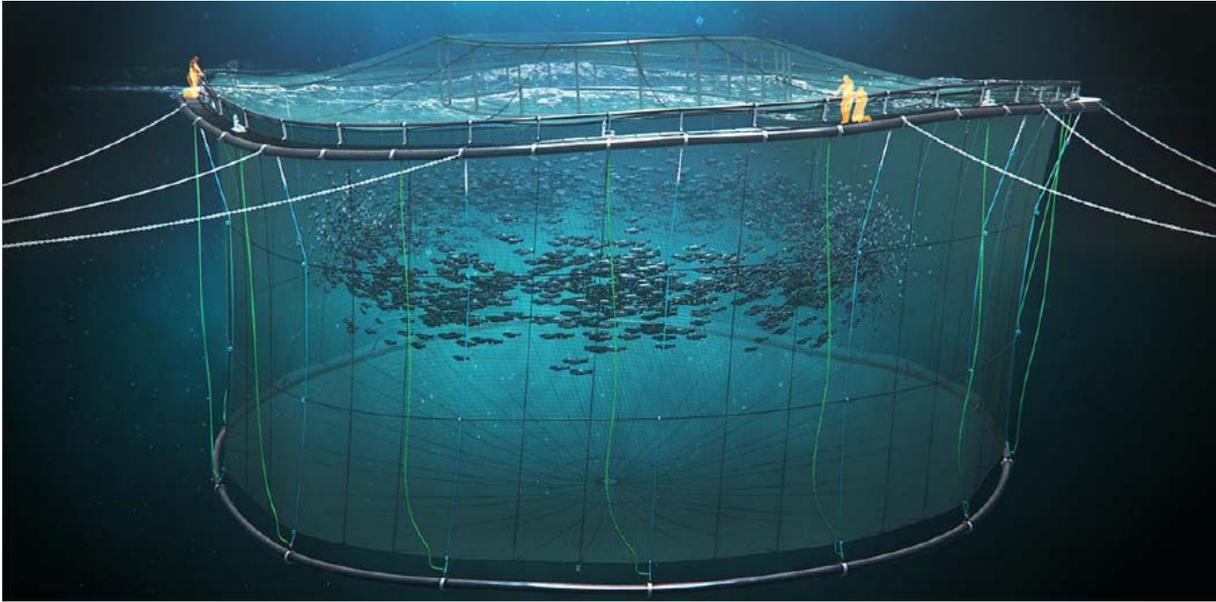


Figure 7. Aqualine’s Midgard System with sinker ring, suspension ropes, and crows feet anchoring. (Video describing the Midgard system (https://youtu.be/ASB-V_H33iI)).

Each sea cage is equipped with 10 customized power winches (Figure 8) which allows for a more efficient and safe work area. Each winch works by lifting and lowering the sinker tube which allows for the entire net to be lifted simultaneously in a single operation without service vessels, cranes and personnel, resulting in no strain on personnel or the netting. Fish can gather and become trapped in pockets of netting leading to a large number of instant mortalities in conventional netting systems. With the Midgard System, uniform lifting of the bottom of the net by winches reduces pockets forming. This is one advantage we can clearly see of the Midgard System compared to other cage/net systems with regard to handling nets with live fish. This system also results in less stress on the fish. The winch is powered by an electric motor (230 V, 50 Hz) with a watertight construction with a 1.5 kW engine that operates at a speed of 1430 rpm (Figure 8). This motor can power the winches to lift the net at a rate of 1 m per minute (rated line pull per winch of 2200 kg each x 10 winches).

Compared to the available information around the local standard for cages in Newfoundland and Labrador, the Aqualine Midgard System maintains a significantly higher level of documentation for the design, engineering, construction and scientific insurance that the system can handle the proposed sites.

In addition to its inhouse engineering team, Aqualine has an accreditation scope for INSP 036 (see Section 1.4.2.4). Our position is, this gives an advantage compared to the local production standard in Newfoundland and Labrador. Aqualine has the required qualifications and accreditation (see Section 1.4.2.4) to carry out full design, production and deployment of the Midgard Cage System to a specific site/location. Also, the Aqualine Midgard System is Certified by DNV GL which confirms and gives this cage system a very high international credibility.



Figure 8. Winch motor operated by sea cage personnel from the sea cage gangway.

In their proposal, Grieg NL is going to use a centralized system called Mortex to automatically and regularly collect dead fish from the sea cages. The system consists of one or two main pipelines from the sea cages to a dewatering system (i.e., separates water from the fish) on the feed barge (Figure 9). The pipelines can range in length from 30 m to 600 m depending on the sea cage layout. The Mortex system is designed to be connected and secured directly to the reinforced cone of each net. This eliminates any possibility of tearing due to free movement and dead fish will be pumped daily via a fully enclosed pipeline system to the feed barge. By collecting mortalities daily this will decrease predator attraction to the cages and minimize disease risk.

Materials for the sea cages will be supplied by Aqualine in Norway as a part of the Aqualine Midgard System. Construction and installation of all sea cage systems and associated moorings will be completed by Aqualine and a third-party supplier, with oversight by Grieg NL. Aqualine has the accreditation scope for INSP 036 which makes them highly qualified for planning and supervising the deployment of the Aqualine Midgard System. The primary vessels for handling the installation and anchoring operation will be third-party service vessels. A total of three vessels will be involved in the installation.

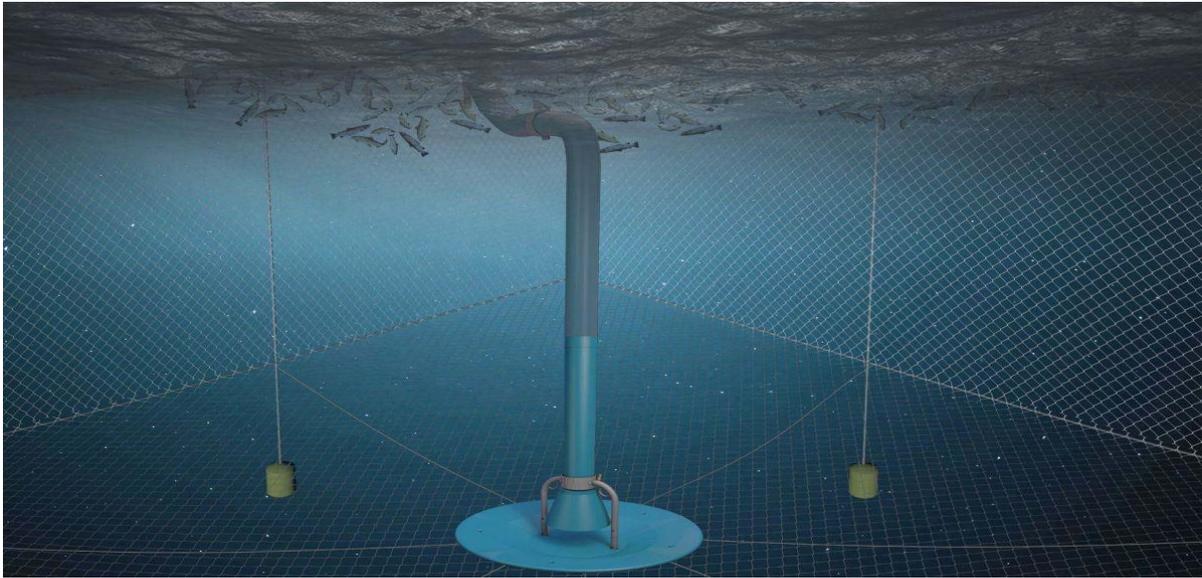


Figure 9. Mortality removal system (i.e., Mortex) in the bottom of the sea cage to collect morts and transfer to surface.

The floating collar is assembled through a series of customized brackets, following the Aqualine manual and procedures (Appendix III) at a designated location determined by the client. The assembled collars then will be towed (without the cage net attached) by a service vessel at a speed < 3 knots to the sea cage sites according to instructions and procedures provided by Aqualine.

The mooring system will be specifically designed for each of the 11 sea cage sites by Aqualine in consideration of oceanographic data collected (bathymetry, currents) (see Section 1.4.4.5). The mooring system is designed by Aqualine in a grid fashion (longitudinal and transversal lines with sea cages connected to each other and securely anchored to the seafloor via a series of fluke anchors, bridles (ropes), grid plates, chain and floats all comprise part of the mooring systems (Figures 10 and 11).

All aspects of the Aqualine Midgard System come with internationally recognized certificates from the providers of components and user fabrication maintenance manuals. Aqualine uses local authorized and qualified partners to follow up on the system for control and recertification of equipment (Appendix III) as they are being used. Recertification follows Risk-Based Inspection (RBI) methodology with inspections performed as well as testing of used components. We have determined that this meets the existing standards available in Newfoundland and Labrador cage system.



Figure 10. Fluke anchor used as moorings for sea cages and barges.

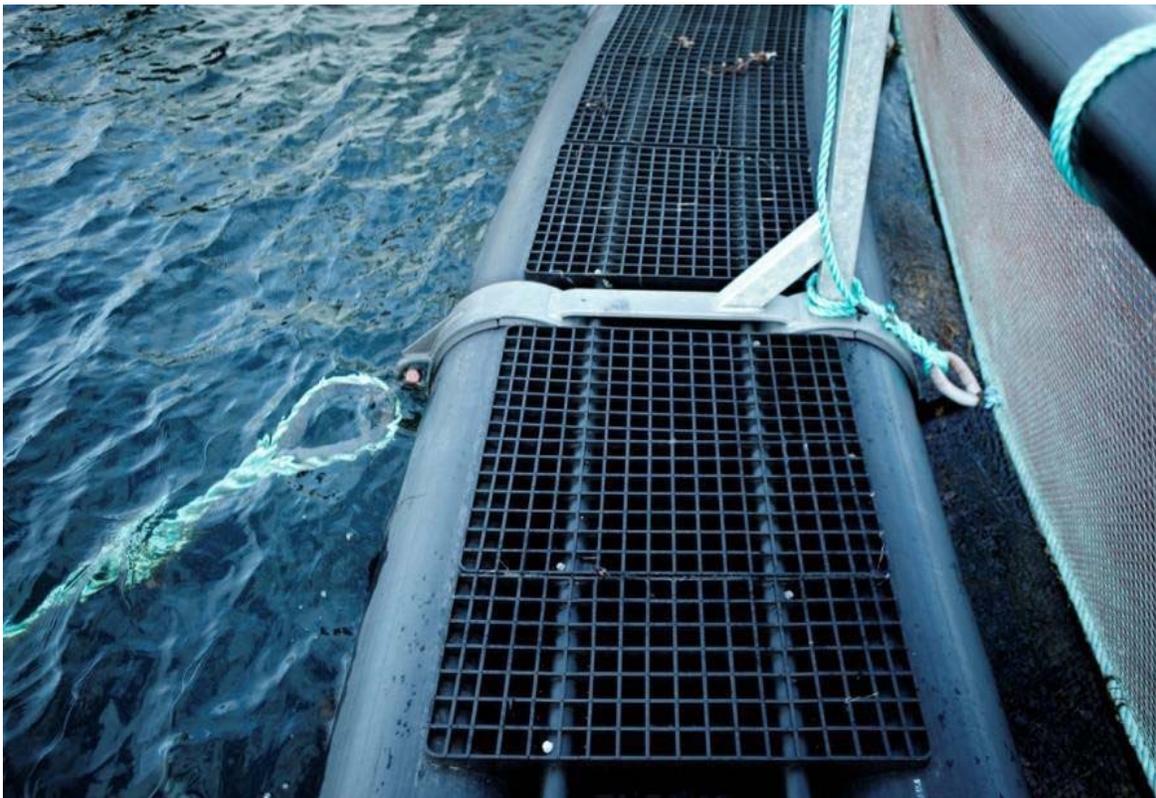


Figure 11. An example of fastening of mooring in the standard mooring bracket. Shackle is secured with a plastic-coated locking wire.

1.4.2 Summary of Successes, Failures, and Lessons Learned

1.4.2.1 Norwegian Technical Standard

Jensen et al. (2010) used Norway as a case study to describe the development and implementation of measures to deal with farmed Atlantic salmon escapes. Correlative evidence suggested that after the Norwegian technical standard (NS 9415) for sea-cage farms took effect in 2004, the total number of escaped Atlantic salmon declined from >600,000 (2001 to 2006) to <200,000 fish per year (2007 to 2009), despite the total number of salmon held in sea-cages increasing by 44% during this period.

The Norwegian Technical standard NS 9415 was implemented through Norwegian legislation on April 1, 2004 and introduced requirements for a technical standard of marine fish farms in Norway. NS 9415 specifies requirements for the design of feed barges, floating collars, net cages and mooring systems to ensure the design can withstand environmental forces as well as the handling and use of equipment. Since the implementation of NS 9415 all new components of a fish farm must be independently certified against the standard. These components include; floating collars, nets, feed barges, and mooring systems. For existing farms and equipment in use before April 1, 2004, a transitional system was in place and ran until 2012. To ensure these fish farms met the requirements of NS 9415, independently accredited companies conducted technical analysis on equipment being used. The data collected was used to determine if the farm could withstand the environmental forces at the specific sites. If the equipment was proven capable for the site, the farm received a certificate indicating proof of capability. The proof of capability was valid for up to 3 years and could be reissued repeatedly until 2012.

After 2012, all main components of a fish farm had to be certified. A revision of NS 9415 occurred in 2009 and resulted in significant developments to the standard. The last major escape incidents occurred in 2005 and 2006, since then the number of reported escapes has been significantly reduced.

Such escapes are becoming more uncommon as the NS 9415 standard is modified and strengthened over time. Research and development to make equipment more robust has been enhanced by a significant amount of industrial research to improve the materials, structures and designs of marine farms. (Jensen et al. 2010)

Out of the 20 largest salmon producing companies in the world, more than half use the Aqualine Midgard System. Companies such as Marine Harvest, LerØy, SalMar, and Bakkafrøst who operate in different geographic locations worldwide, use the Aqualine Midgard System to allow safe and secure farming in very exposed locations.

SalMar (<https://www.salmar.no/en/>) is one of the world's largest producers of farmed salmon. Owning 100 licenses for marine production of Atlantic salmon in Norway including; 68 licenses

in the Company's principal producing region in Mid-Norway (Trøndelag and Nordmøre) and 32 licenses in Northern-Norway through SalMar's wholly owned subsidiary SalMar Nord AS.

SalMar expressed their reason for using the Aqualine Midgard System in a report titled "*Operation of Green Permits: Experience and Evaluation, January 2017*". It is stated that SalMar chose the Midgard system because it is thought to be a system that significantly reduces the possibility of fish escapes. The system has been developed over several years, to answer some of the challenges posed from existing sea cage systems. Two major causes of escapes in Norwegian aquaculture have been systems that caused chafing on the floating collar, holes in nets and human error associated with work operations. Once they began using the Aqualine Midgard System on their sites in Northern Norway, it eliminated most of the risk and problem the traditional cages systems they were struggling with. Use of the 10 winches on the cages reduced the need of support vessels while the sinker tube and integrated mooring system made the movement and work on the cages more effective and safer.

SalMar has not had any escapes related to Aqualine Midgard System. Experience shows that the need for regular maintenance work is reduced, especially in terms of wear and tear on the floating collar. Overall, it has been a good experience and SalMar considers the Aqualine Midgard System an improved technology that is significantly safer in terms of Health, Safety, and the Environment for employees and the risk of fish escapes.

1.4.2.2 Experience to Date

Many of Aqualine's clientele (Table 1) have started to replace their traditional cage systems with the Aqualine Midgard System. Since the industry has moved to more exposed geographic locations, the demand for the Aqualine Midgard System has increased exponentially since 2013 in places such as Norway (which produces approx. 60% of the world's salmon) UK, Faroe Islands, Iceland, Chile and North America. Marine Harvest, the world largest producer of Salmon is in the process of upgrading or replacing traditional cage systems to the Midgard System on many of their most exposed locations world wide. Aqualine has today around 50% of the cage system market in Norway and their main product for cage system is the Aqualine Midgard System. The Aqualine Midgard System is in use today on sites that are exposed to 6-7 meter significant wave heights (M. Soreide, CTO, Aqualine, pers. comm., 23 April 2018,). This is within maximum significant wave heights of any of the proposed sites in Placentia Bay they may be exposed to (see Table 3).

According to Aqualine, feedback from their clients on the Aqualine Midgard System has only been positive. None of their clientele so far, has had any escapes from the Aqualine Midgard System which can be partly seen in the escape statistic from the Norwegian Directorate of Fisheries from 2014 (when the Midgard System deployed a large number of systems) to present day (with more than 1000 units in use world-wide).

Table 1. Aqualine Clientele List.

AQUALINE CLIENTELE LIST	
ÅMØY FISKEOPPDRETT	LERØY MIDT AS
AAKVIK SETTEFISK	LIGHTHOUSE CALEDONIA, SCOTLAND
ALSAKER FJORDBRUK	LUNA
ALSAKER FJORDBRUK	MÅSØVAL FISKEOPPDRETT
ANDROMEDA GROUP	MARINE HARVEST
AQUA GEN	MARINE HARVEST CANADA
ARNARLAX	MARINE HARVEST FÆRØYENE
ATLANTIC HALIBUT	MARINE HARVEST IRELAND
BALLANGEN SJØFARM	MARINE HARVEST IRLAND
BJØRØYA FISKEOPPDRETT	MARINE HARVEST NORWAY
BOLSTAD FJORDBRUK	MARINE HARVEST SCOTLAND
BREMNES SEASHORE	MIDT-NORSK HAVBRUK
BRILLIANT FISKEOPPDRETT	NORDLAKS AS
CERMAQ AS	NRS FEØY AS
CLAIRE ISLAND SEAFARMS, IRELAND	OPEN BLUE SEA FARMS, PANAMA
ELLINGSEN SEAFOOD	PAN FISH P/F LUNA
ERFJORD STAMFISK	PETUNA AQUACULTURE, TASMANIA
ERVIK LAKS OG ØRRET	PHUKET AQUACULTURE RESEARCH STATION, THAILAND
EWOS INNOVATION	PROTEIN GOSTAR SINA CO.
FIRDA SJØFARMER AS SOGN	RØVÆR FJORDBRUK
FJELLBERG FJORDBRUK	RUSSIAN SALMON
FJORD MARIN COD	SALMAR
FJORD SEAFOOD	SALMAR NORD
GRIEG COD FARMING	SALMAR RAUMA
GRIEG SEAFOOD	SALMONES HUMBOLDT, CHILE
HJALTLAND SEAFARMS, SHETLAND	SALMONES PACIFIC STAR, CHILE
HUON AQUACULTURE, TASMANIA	SCOTTISH SEA FARMS
INDIAN OCEAN FRESH	SENJA SJØFARM
KNUTSHAUGFISK	SINKABERG-HANSEN FISKEOPPDRETT
KOBBEVIK OG FURUHOLMEN	SINKABERG-HANSEN, VIKNA
KOBBVÅGLAKS	SJØTROLL HAVBRUK
KOBBVAGLAKS AS	SVANØY HAVBRUK
LAXAR	TOFTØY FJORDBRUK AS
LERØY AURORA AS	TOMBRE FISKEANLEGG
LERØY AUSTEVOLL	VEST MARIN PRODUKSJON
LERØY HYDROTECH	VESTLAX, FARDE ISLANDS

Aqualine’s first commercial delivery of the Aqualine Midgard System was in 2013, continuing distribution throughout 2017 deploying up to 800 systems. According to the Norwegian Directorate of Fisheries, the number of escapes has decreased considerably since 2013 (www.fiskeridir.no) (Figure 12). The escape report includes land-based as well as marine escapes but this decrease in escaped fish correlates with the deployment and continuous use of the Midgard System.

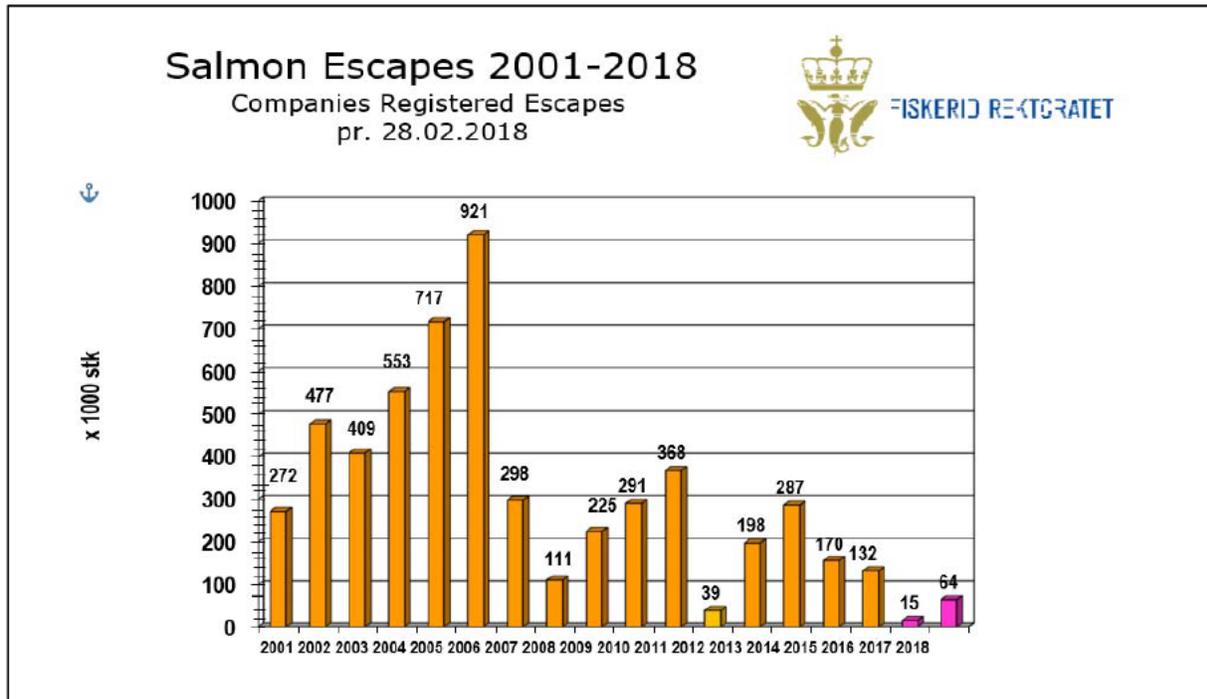


Figure 12. Salmon escapes 2001-2018 for registered companies in Norway.

Events that may result in escapes can be a result of external, operational, or structural causes. External causes are those outside of the nets, for example an attack by predators. Operational causes occur during operation and may be due to handling errors. Structural causes can typically be a failure of equipment or contact between components. In Norway in 2017 events and reported escapes of all fish species (land-based and marine-based) was recorded based on these cause categories (Figures 13 and 14).

A total of 111 events were reported to the Directorate of Fisheries in 2017. Of these there were 71 events in which the companies concluded that there were no fish escapes. Of the events in 2017, 40 percent are categorized for operational reasons. Of these, there are single events related to handling of harvest nets that led to about 8 500 escaped salmon and rainbow trout.

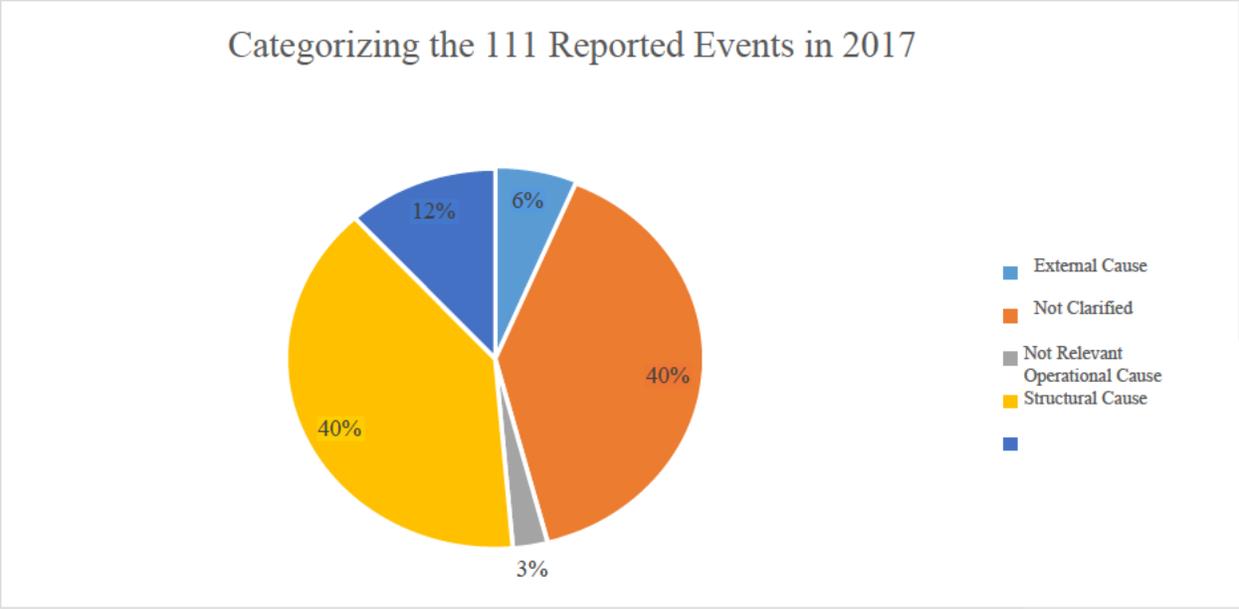


Figure 13. Categorizing the 111 reported events in Norway, 2017 from the Norwegian Directorate of Fisheries.

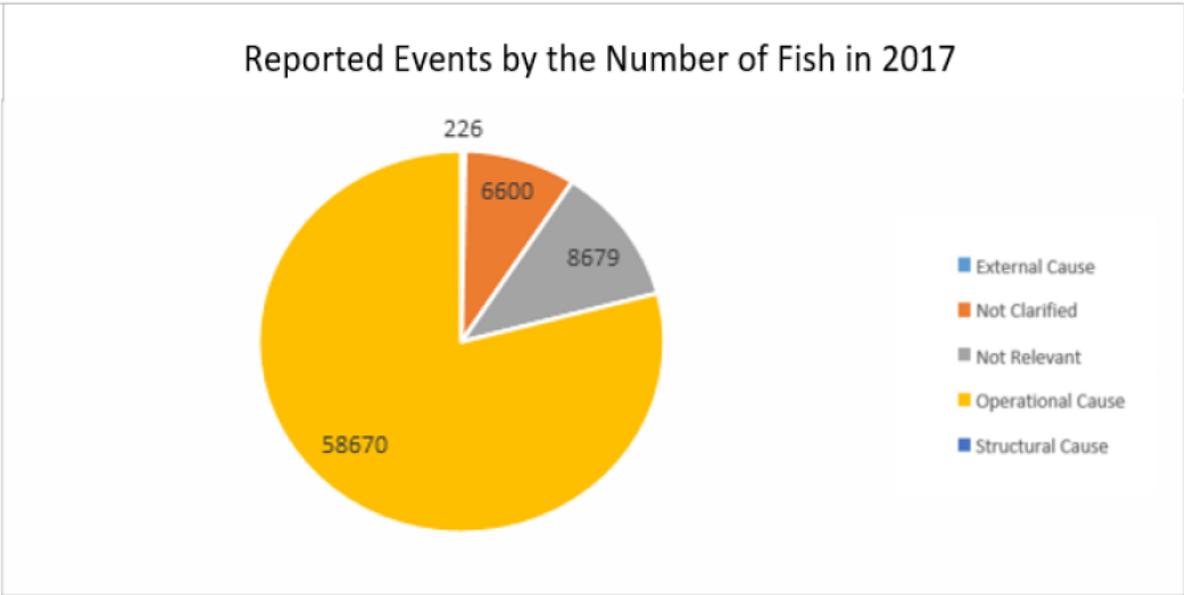


Figure 14. Reported events by the number of escaped fish in Norway, 2017 from the Norwegian Directorate of Fisheries. *Note that some reasons are not relevant to categorize and there are also clarifications that cannot connect to any of the categories.

Structural causes accounted for 12 percent of the events in 2017. Under structural causes of marine installations, tearing of shackles from crow feet attachment to the net and an inspection hatch from the counter on board a well boat which led to the escape of approximately 7 300 salmon. In addition, 50,000 halibut escaped from a closed containment facility as the result of a loose drainage grate due to stormy weather. At a land-based facility, there was an incident related to a hole in a concrete barrier which led to 1,400 escaped rainbow trout.

In the case of external causes, the most extensive escape with 200 escaped rainbow trout is linked to dogfish attacks. In 40 percent of the events, the cause is not clarified. In this category, 6 600 escaped fish have been registered, including an event of 4,100 char.

The Aqualine Midgard System, with its winches to raise and lower nets, cameras to monitor, and pumping of the fish during harvesting all reduce the possibility of human error and prevent possible fish escapes. The Aqualine Midgard System has undergone rigid testing and is certified to withstand significant wave heights of up to 9m (Appendix IV.A. SINTEF Report)

In Canada, there are several primary reasons which have led to the escape and accidental release of finfish from sea farms including personnel errors made during routine fish handling procedures and net damage caused by weather, ice, and predators. From 2010-2016 in Newfoundland and Labrador there have been five reported incidents of salmon escapes from sea farms and at least nine breaches in nets with no official report of escapes. Of the five reported incidents two were attributed to personnel errors made during harvesting, two were attributable to extreme weather, and one was attributed to a predator strike (possibly sharks; DFO 2017a).

The nine net breaches, which were reported in 2012, were attributed to sharks and tunas. The reported salmon escapes in Newfoundland and Labrador occurred during operation of a different type of sea cage system than the Aqualine Midgard System Grieg NL is proposing for use (DFO 2017a).

1.4.2.3 Summary/Evaluation

Through our review we are convinced, based on the number of units sold to the industry worldwide since 2013, including some of the world leading salmon farming companies, the proclaimed ability of the Aqualine Midgard System has been confirmed by the users. There is no report of major failure of the system and no reported escapes as shown in Section 1.4.2.2 (Figures 12, 13, and 14) some of the locations where the Aqualine Midgard System is being used, the system is operating in areas as equally or more exposed and harsh as Placentia Bay.

During our review it was recognized that from the late 60's to mid-2000s most equipment for aquaculture was not standardized. During the 2000s the aquaculture industry in Norway moved

from a non-controlled non-monitored industry to the implementation of a higher-level standard and controlled fabrication process.

Aqualine reports that their biggest commercial success is the development and commercial launch of the Aqualine Midgard System in 2013. The sole number of units sold from launch to present day of a very expensive cage system speaks volumes. The industry has acknowledged that the promised quality and punctuality of the Aqualine Midgard System is accurate and meets the expectation of the users.

The main advantages for the Aqualine Midgard System as reported from the users are:

- The tailored design, production and deployment for specific site locations.
- The system has been tested, documented, and proven to handle extremely exposed locations.
- The customized sinker tube with the correct weight and rigidity to provide optimum interplay throughout the net cage system
- The sinker ring suspended directly from the net baseline rope maintaining the shape of the net providing easy and constant volume for the fish
- The lifting/lowering ropes are completely slack and independent of the rest of the system and in no danger of encountering the net. This reduces the risk of escape due to tearing.
- The winch system for raising and lowering the sinker tube is evenly located around the entire ring and under full control
- It reduces the number of service vessels needed for operating the system at no risk to personnel.

1.4.2.4 Certifications

Aqualine

Aqualine has certifications in place from several accredited institutions including SINTEF, DNV GL and has also received Norwegian Accreditation INSP 036 as an inspection body type C.

Based on many years of fish farming experience and the requirements from Standards and Regulations, Aqualine delivers robust cage technology for harsh environments all over the world. To date there have been no reported fish escapes during production of 350 million fish (~2 million tonnes) in locations such as Norway, Faroe Islands, and Scotland using the Midgard system.

Aqualine is a Research and Development system supplier focusing on strong requirements to products. Service and After Market Departments assist customers with respect to maintenance and operations of the Aqualine Midgard Systems. Aqualine has established a Marine Engineering

Department that has been a determined strategy and focus point for Aqualine since 2014. This group consists of engineers with competence from design of risk-based equipment and solutions in aquaculture and from the offshore oil and gas business. These engineers are frequently at conferences to gain experiences from other parts of the aquaculture industry ensuring Aqualine is constantly improving.

Aqualine's Marine Engineering Department undertakes:

- Certification
- Mooring analyses
- Constructional analyses (Element and 3D+2D-analyses)
- Capacity analyses for certification and deliverables
- Software development (Matlab)
- Manual calculations
- Research and development
- All deliverables (project planning, analyses, drawings, installation)
- Drawing and production of components
- Site visits
- Project management

Aqualine has extensive experience within calculations and dimensioning of marine constructions, including structural and hydrodynamic analysis for fish farm mooring, barge mooring, cages, nets and special components. The engineering department covers a wide range of competence and knowledge on fish farming and offshore constructions. Hence, developing very cost-effective and reliable solutions for any location of fish farming. All evaluations consider site specific locations and customer specific scope and requirements. Furthermore, all calculations are done according to current regulations and standards.

So far, there have not been any accidents with the Aqualine Midgard System caused by external factors such as ship collisions, wrong use of equipment, human errors and so on. Aqualine is undertaking a lot of risk-based evaluations together with customers and various companies but can not be 100% safe against such accidents. However, the Midgard System is designed to be able to withstand these loads to avoid severe incidents including breaks in mooring lines as well as puncturing, disappearance or loss of floating parts (NS 9415 [6.5.6.1], [6.5.6.2], [6.5.6.3]).

In 2013, Aqualine was nominated for Aqua Nor's Innovation Award. This award focuses on the seafood industry internationally and in Norway, with efforts in innovation and R&D in the fields of environment, technology, biology and resource management. The Mid-Norway Chamber of Commerce and Industry referred to Aqualine's work on the Midgard System as part of the reason for awarding the company the title of Company of the Year in 2014 and in April 2015, Aqualine won the NHO Mid-Norway Innovation Award for systematic and long-term efforts in research, development and innovation for the system.

It must be noted that the free trade agreement (FTA) between Canada and the European Free Trade Association (EFTA) and the Comprehensive Economic and Trade Agreement (CETA) between EU and Canada both may have an impact on certification recognition in Canada.

DNV GL

DNV GL (<https://www.dnvgl.com/>) is a globally leading quality assurance and risk management company operating in more than 100 countries. The company's purpose is to safeguarding life, property and the environment. DNV GL has all the accreditations for aquaculture in Norway, being an independent certification body and inspection body in the aquaculture industry. DNV GL provides classification, certification technical assurance, software and independent expert advisory services to the maritime, oil and gas, power, renewables industries as well as, supply chain and data management services. The company's purpose is to safeguard life, property and the environment. DNV GL has all the accreditations for aquaculture in Norway, being an independent certification body and inspection body in the aquaculture industry. Aqualine has been certified by DNV GL for the floating collars used in the Midgard system (Appendix IV.B). These tests have been conducted with realistic cage models at SINTEF. Furthermore, qualification was also conducted through on-site measurements at sea and compared to the model tests prior to industrialization. The highest wave conditions during model testing have been significant wave heights of 9 meters, equaling about 17-18 meters maximum wave height and corresponding current velocity applied is above 2 metric knots.

We have determined that DNV GL with its certification of these cages furthermore ensures that the Aqualine Midgard System meets both international standards for fish farming cage systems as well as the available standards for fish farming cages in Newfoundland and Labrador.

SINTEF

Aqualine Midgard System is a unique technical solution specialized for farming salmon and can be used for all types of marine based aquaculture. The System is designed and engineered by Aqualine and verified by advanced model testing at SINTEF OCEAN (<https://www.sintef.no/en/>). SINTEF Ocean is an independent research organization and a world leader in technological research in the field of exposed aquaculture, with structural engineering and hydrodynamics as important subjects. SINTEF supports research and development in many maritime industries including marine vessels, fishing, aquaculture and oil and gas. With expertise in hydrodynamics and construction engineering, SINTEF Ocean offers model and full-scale testing in their Ocean Basin. Total environment simulations including wind, waves and currents provide testing in realistic conditions. The Aqualine Midgard System has been tested by SINTEF in their Ocean Basin system in a number of simulated wave conditions and current speeds (Appendix IV.A).

SINTEF has previously worked in conjunction with the Fisheries and Marine Institute of Memorial University of Newfoundland (<https://www.mi.mun.ca/>) on a number of projects (Appendix IV.C).

We have determined that the use of an international, well acknowledged research organization such as SINTEF carrying out tests and confirming the type of sea conditions the Aqualine Midgard System can withstand meets the standards available for testing and documentation of cages in Newfoundland and Labrador.

INSP 036

In August 2012, Aqualine received the Norwegian Accreditation INSP 036 as an inspection body type C (Appendix IV.D). Type C inspection bodies can perform inspections on both their own organisation and external organisation and meets the requirements in NS-EN ISO/IEC 17020. This accreditation allows Aqualine to design and engineer site specific systems while covering the field of inspection for mooring analysis in new, used, in-use, rebuilt, and moved structures. The scope of this field includes requirements for site surveys, risk analysis, design, dimensioning production, installation and operation following NYTEK and NS 9415:2009 regulations.

In addition to its inhouse engineering team, Aqualine has an accreditation scope for INSP 036. Our position is, this gives an advantage compared to the local production standard in Newfoundland and Labrador. Aqualine has the required qualifications and accreditation (see Section 1.4.2.4) to carry out full design, production and deployment of the Midgard Cage System to a specific site/location. Also, the Aqualine Midgard System is Certified by DNV GL which confirms and gives this cage system a very high international credibility.

AON

AON offers a range of sophisticated advisory and consulting services in risk control and risk management, reinsurance, and human capital. They design, structure and implement solutions that may involve traditional insurance products or risk-transfer programs, alternative financing techniques, or entirely new products to address a specific problem. AON insists that all operators only use and operate fully certified and accredited cage systems which meet internationally recognized standards (Appendix IV.E).

We have determined that the procedures that are being used by Aqualine, combined with the overall site-specific design based on the above environmental and sea bed information ensures that the Aqualine Midgard System meets the required standards as described in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for cage systems (Appendix V).

1.4.2.5 SINTEF Model Testing

SINTEF Ocean (<https://www.sintef.no/en/>), performs research and development within maritime, offshore oil and gas, renewable energy, aquaculture, bio marine and marine environmental technology for domestic and international trade and industry. The Marine Technology Centre in Trondheim, Norway, consists of two partners: SINTEF Ocean and Norway's Technical and Scientific University in Trondheim (<https://www.ntnu.edu/>). The Marine Technology Centre is one of the strongest research and educational institutions within Marine Hydrodynamics and Marine Structures worldwide. Its laboratories built in 1950 (Towing Tank) and 1980 (Ocean Basin) were by the outset considered as national laboratories (Figures 15 and 16). The laboratories are central suppliers of technology to the three largest export industries of Norway: offshore oil and gas, fisheries and aquaculture and shipping.

Hydrodynamic model testing will have three different aims:

- To obtain relevant design data to verify performance of actual concepts for ships and other marine structures
- To verify and calibrate theoretical methods and numerical codes
- To obtain a better understanding of physical problems

The Midgard Model Tests

Since 2012 SINTEF Ocean has performed several model test campaigns with the Aqualine Midgard System (Appendix IV.A).

The first model test campaign was conducted in November 2012. The model tests were performed in a linear scale of 1:16. The objective of the model tests were to study the behavior of the Aqualine Midgard System in various wave and current conditions.

The present model test set-up consisted of a cage model with net and mooring system. The diameter of the cage model was equal to 50 m in full scale. The net was purposely built for these model tests, and it had cylindrical shape with vertical side walls and a conical bottom. Different configurations of floater tubes and bottom rings were tested together with different weights in the conical end of the net. The mooring system consisted of a quadratic, horizontal frame mooring system spread out with 4 buoys and 8 mooring lines attached to the seabed. Another 8 horizontal mooring lines facilitated the connection between the frame mooring system and the fish farm.



Figure 15. SINTEF Ocean Basin Laboratory. (<https://www.sintef.no/en/all-laboratories/ocean-laboratory/>)



Figure 16. SINTEF Towing Tank. (<https://www.sintef.no/en/all-laboratories/towing-tanks/>)

Forces (strength) and accelerations (increase in speed) were measured at different connection points between the net, the cage and the mooring lines. For this set-up 6 linear accelerometers were used together with 14 tension rings. Further, wave heights and current speed were measured. Video recordings were taken from both above and below water cameras. The model was installed in the middle of the Ocean Basin and the water depth was set equal to 52 m. The mooring lines were attached to the bottom at predefined locations.

A total of 6 different environmental conditions were used for these tests. They consisted of 3 different wave conditions and 2 current speeds, 0.5 m/s and 0.7 m/s. The following wave conditions were calibrated prior to the testing with the wave spectrum formulation according to the JONSWAP formulation (Table 2):

Table 2. Wave conditions for model testing Aqualine Midgard System.

No.	Hs (m)	Tp (s)	Vc (m/s)
1	4.5	8.0	0.0
2	4.5	8.0	0.5
3	4.5	8.0	0.7
4	3.8	13.2	0.7
5	2.5	6.0	0.7
6	2.5	6.0	0.5

Hs – Significant Wave Height

Tp – Peak Period for Waves

Vc – Current Velocity

The waves were calibrated for a test duration corresponding to 3 hours full scale time. The full test program consisted of:

- 28 irregular wave tests with current
- 1 irregular wave test without current
- 2 current only tests,

and included parameter variations of rigging of the fish farm, weight changes and elasticity variations.

SINTEF Ocean has developed applied and theoretical expertise in structures and systems for sea-based aquaculture. SINTEF Ocean is a world leader in technological research in the field of exposed aquaculture structures, with structural engineering and hydrodynamics as important subjects. SINTEF Ocean has several ongoing research programs on aquaculture. The test methodology used for this project has been developed through decades and is state-of the art.

We have determined that SINTEF Ocean Research Center has proven their credibility through decades of development and testing of products for the marine environment (see <https://www.sintef.no/en/> and Appendix IV.C. Their focus on exposed aquaculture structures, the use of this knowledge base, as well as their engineering capacity ensures the high-end quality of procedures and development for the Aqualine Midgard System. The detailed documentation of the system, the approval of the quality from the aquaculture industry, and the many certifications and standards the design is built on, ensures that the Aqualine Midgard System meets the standards in Newfoundland and Labrador for plastic circle cage systems as stated in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador.

1.4.3 Methods and Results of Structural and Operational Tests

The floating collar is one of the key components of the Aqualine Midgard System. We have reviewed the floating collar as well as the components that comprise the Aqualine Midgard System as described in the guidelines. Below is a diagram that highlights the various components and will be reviewed through this section (Figure 17).

The floating collar is comprised of two floater tubes (Figure 17, Checkpoint 1) being fabricated from HDPE (High Density Polyethylene) pipe in compliance with the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador, March 2014. It should be noted that Aqualine utilizes DR11 pipes, which is especially designed for pipes with larger diameter and thicker walls that are used in designs which need to withstand severe strain/loads. The Aqualine Midgard System utilizes DR11 for the whole range of pipe diameters in their system. One of the main advantages of this standard of pipe is excellent resistance to rapid crack propagation and slow crack growth. This gives the crew on sites the ability to identify gradual deterioration and prevent major incidents. The Aqualine Midgard System uses closed cell foam that cannot absorb water (open cell foam absorbs water) in their floating collar pipes which also gives more rigidity (Figure 17, Checkpoint 3).

The floating collar is of similar shape to the circle cages traditionally used in Newfoundland and Labrador as described in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (Appendix V). The system also meets the standard described in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for the net and mooring system. As an observation we notice that the documentation that describes the criteria for the design, production and deployment of the Midgard Cage System is substantial. These documentations are also based on and supported by relevant international excepted third-party industrial standards and certification providers.

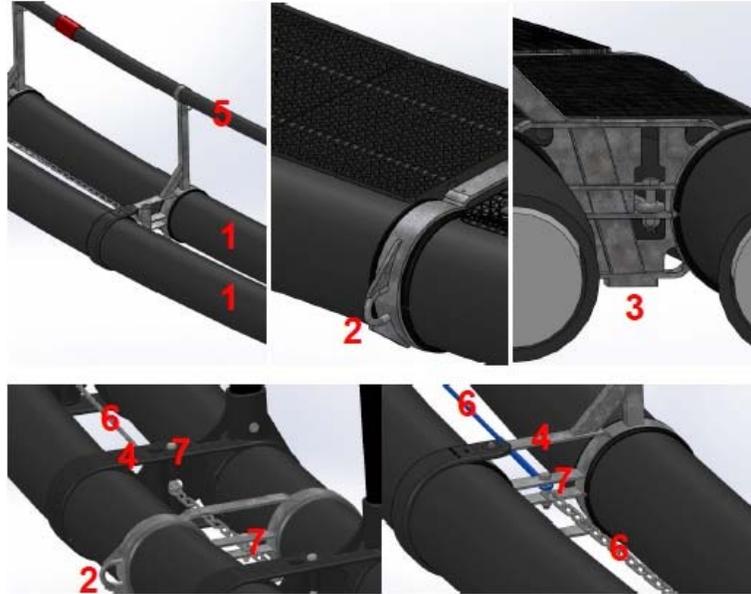


Figure 17. Checkpoints for inspection and maintenance of Aqualine's Midgard System.

The mooring clamps (Figure 17, Checkpoints 2 and 3) and other steel components are designed with a galvanized coating to prevent rusting and corrosion causing failures in operation. The number of clamps and their exact position on the floating collar are calculated based on the in-depth testing of the system both at SINTEF Ocean as well as in full scale marine operation. The clamp system allows for easy securing of mooring ropes/chains and are equipped with bushings (wear pads) to prevent chafing and abrasion on the floating collar. The plastic and steel straps (Figure 17, Checkpoint 4) provides support to keep the two floater pipes positioned and operational as designed. They also act as the structural support for holding the safety hand rail (Figure 17, Checkpoint 5). The safety chain (Figure 17, Checkpoint 6) is offering additional support in case of structural damage, reducing the possibilities for the floating collar to break apart.

The gangway that sits on top of the two rings (see Figures 8 and 11) offers a safer working environment as well as an easier way of carrying out surface inspection on the system than similar cage systems currently in use. The gangway has no impact on free movement of the floating collar as it is a pliable system.

As noted above in our review of the components that are being used in the Aqualine Midgard System, these are components and products that have been utilized in the mining and oil and gas sectors in the Province for years. Besides their use in these sectors, these components have also formed the basis of the cages technology used internationally for the industries. These design standards that Aqualine has built their system on covers design processes, material, production and deployment. Since environmental conditions may have an impact on marine construction, Aqualine includes in their design for the Aqualine Midgard System, site specific environmental conditions. Aqualine has in-house the accreditation necessary for these kind of technical assessments (Appendix IV) and they use internationally accepted companies offering

environmental services for gathering reliable information from each local site the Aqualine Midgard System is being designed for. The proposed Aqualine Midgard System for Placentia Bay has been planned and based on the above criteria from Aqualine. Compared to the information available in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for cage systems, we have determined that the Aqualine Midgard System meets all these requirements.

1.4.3.1 Review of Assembly Protocols

The strength of an aquaculture cage system is only as strong as the weakest point. Looking at all the components in the Aqualine Midgard System and certifications that follow them, one of the main importance parts is the fusion (thermal bonding) of the HDPE when assembling the system. Aqualine utilizes third-parties that meet the following standards as set out by the Plastic Pipe Institute

- Aqualine contractors meet regulations requiring that joints in polyethylene piping shall be designed and installed to withstand the longitudinal forces caused by contraction of the pipes or by external loadings.
- Aqualine contractors meet the Plastic Pipe Institutes Requirements that joints in polyethylene piping shall be made by personnel who are qualified in the applicable procedures. Under the TN-42 training guide.
- Aqualine contractors meet the ASTM standards require that heat fusion joints shall be made in accordance with documented procedures as per the Plastic Pipe Institute that have been proven by tests. Fusion tools thermostatically controlled and electrically heated must be designed specifically for butt fusion (heating ends and simultaneously pressing together) and must be used only for the purpose for which they are designed (Figure 18). Direct application of heat using a torch or open flame is prohibited



Figure 18. HDPE fusion of pipe.

- Aqualine contractors require heat fusion joints shall not be made between different grades of polyethylene pipe materials, unless their compatibility is certified by the manufacturers or proven by tests (Figure 19).



Figure 19. Data logger reports of process of HDPE pipe fusion on computer and tablet.

- Aqualine contractors are trained to and perform work to ASTM (American Society for Testing and Materials, Canada operates under the ASTM guidelines) F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings (Figure 20).

ASTM F2620-13 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings (excerpt)

1.1 This practice describes procedures for making joints with polyethylene (PE) pipe and fittings by means of heat fusion joining in, but not limited to, a field environment. Other suitable heat fusion joining procedures are available from various sources including pipe and fitting manufacturers. This standard does not purport to address all possible heat fusion joining procedures, or to preclude the use of qualified procedures developed by other parties that have been proved to produce reliable heat fusion joints.

4.1 The procedures described in Sections 7 – 9 are primarily intended for (but not limited to) field joining of polyethylene (PE) pipe and fittings, using suitable equipment and appropriate environmental control procedures. When properly implemented, strong pressure/leak-tight joints are produced. When these joints are destructively tested, the failure occurs outside the fusion joined area.

Figure 20. Excerpt of ASTM Standard used for heat fusion joining.

In addition, the Aqualine Midgard System is fabricated in compliance with the industry standards as outlined by the Plastic Pipe Institute in *the second edition of the handbook for Polyethylene piping* (Appendix VI).

We have determined that Aqualine and their local sourced contractors follow the industry standards and meet all requirements as set forth in the Plastic Pipe Institute (PPI) and Municipal Advisory Board (MAB) Procedures as well as ASTM standards referenced above in this section. We have determined this will also meet the requirements in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for an aquaculture cage system.

1.4.3.2 Fabrication Inspections

To ensure fabrication inspection completion, the contractor is required by Aqualine to utilize data loggers on all equipment to give real time reporting with printed quantitative information about all joints being fused (Figure 21). This process has become industry standard in the oil, gas and mining sectors and Aqualine are following this standard for work being performed when fabricating the floating collar of the Aqualine Midgard System.



Figure 21. Data Logger from McElroy used to capture information related to fusion operations.

The need for better record keeping and increased accountability is growing among those who build and manage pipeline infrastructures. New standards, including ASTM F3124 Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings, have been implemented to govern the collection of data from plastic pipe fusions (Figure 22). The Data Logger from McElroy meets the ASTM requirements by capturing the most important information related to fusion operations. It is now easier than ever before to add improved traceability and a higher level of assurance that pipelines were fused properly before they go into service.

Fabrication and assembly of the Aqualine Midgard System will follow the respective ASTM (American Society of Testing and Materials) standards combined with the detailed manual and procedures from Aqualine. This create a log and documentation that the production and assembly of the Aqualine Midgard System has followed the design calculations by Aqualine Engineers to meet the specific requirement for the various sites in Placentia Bay.

ASTM F3124 Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings (Excerpt)

1.1 This practice specifies the data recording information that is recorded, when data recording equipment is used, on butt fusion joints in a plastic piping system in order to compare the procedure used in making the joint to the heat butt fusion joining procedure specified. This practice is suitable for use with all heat butt fusion joining procedures that require measurable time and pressure profiles, such as Practice F2620, Specification F2785, Specification F2945 international standards or other qualified procedures. This practice applies to hydraulically operated heat butt fusion machines only and does not apply to manually operated fusion machines or specialized fabrication equipment for fittings in a controlled environment with proprietary procedures and processes.

Figure 22. Excerpt of ASTM Standard used for data recording.

We have determined and in consultation with the equipment suppliers such as McElroy, the utilization of approved industrial technical standards and the Plastic Pipe Institute's best practices and installation inspection test plan will ensure that the Aqualine Midgard System will provide the detailed level of assembly inspection to ensure that the design criteria are in compliance with all needed standards for production of an aquaculture cage system in Newfoundland and Labrador.

1.4.3.3 Operational Inspections

During operations, inspections will continue to be the critical component in ensuring that the Aqualine Midgard System is functioning at optimal design strength to prevent escapes from the cages and safety to the workers. This has been highlighted by Aqualine to present the level of detail that will be utilized and will be done by following a rigorous inspection plan as outlined in Aqualine's User Manual for floating collars (Appendix III).

In looking at the HDPE components a variety of test methods are available to ensure that pipe has not seen deterioration due to contact with elements, wear from metal components, and strains from mooring system. Ultrasonic testing will be used, in which the reflection of the wave can measure the differentials along the pipe offering the following benefits (Figures 23 and 24):

- Uses a sweep of angles, which greatly increases the probability of detection of defects.
- When optimized, provides coverage of nearly 100% of the fused joint.
- Only requires access from one side of the joint at a time.
- Data represented in side, top, end, and cylindrical-side views, which can be viewed during "live" scanning, or defined during analysis after the data has been recorded.

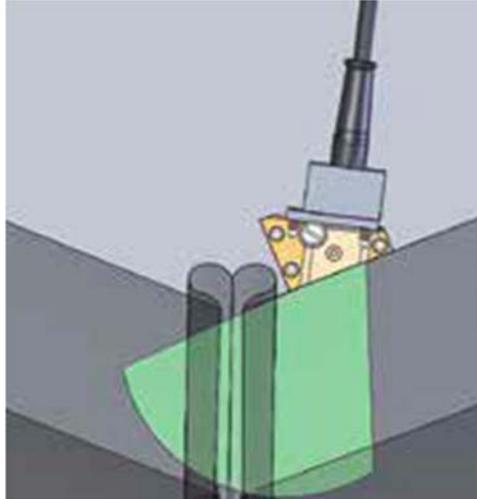


Figure 23. Transducer for ultrasonic fusion testing.



Figure 24. Live scanning data of ultrasonic testing of fused joint.

In addition to ultrasonic testing of the piping the utilization of surveying and corrosion inspection is to be completed on metallic components to ensure that design strength is not affected and is documented as presented below (Figure 25).

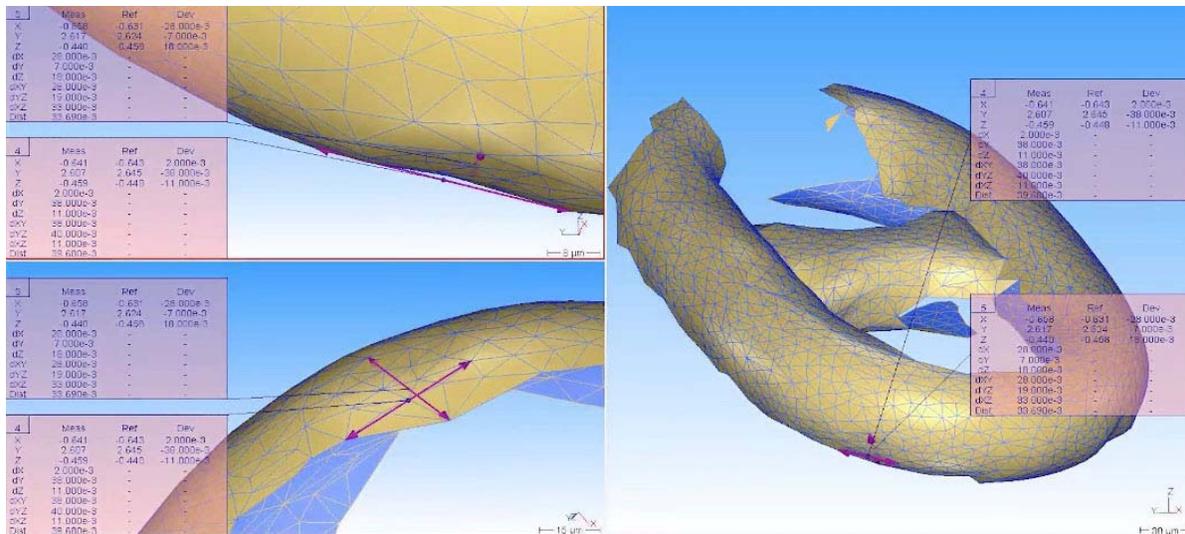


Figure 25. Operational survey and corrosion inspection of metallic components (wear on chain).

We have determined that the inspection documentation that has been provided for review in the user manual, combined with the inspection protocols that Aqualine has provided to Grieg NL will ensure that the design standard is maintained through operations to keep the Aqualine Midgard System at an optimal operation standard.

1.4.4 Prediction of the Performance of Sea Cages in the Study Area

There are many companies using Aqualine Midgard Systems at exposed locations which are equally or more exposed than Placentia Bay. These include among others Arnarlax in Iceland (Figures 26 and 27), Marine Harvest Faroe Islands (Figures 28 and 29), Marine Harvest Scotland (Figure 30), SalMar Nord in Norway (Figure 31), and Marine Harvest in British Columbia, Canada.

From the Icelandic Met Office (http://en.vedur.is/weather/climate_in_iceland/), the climate of Iceland is subarctic near the southern coastal area and the tundra inland in the highlands. The island lies in the path of the North Atlantic Current, which makes its climate more temperate than would be expected for its latitude just south of the Arctic Circle. This effect is aided by the Irminger Current, which also helps to moderate the island's temperature and results in significant wave heights of approximately 2m. The weather in Iceland can be especially variable and experience cooler summers and severe winter storms with heavy wind. The sea cage sites located in Iceland are comparable to the proposed sea sites located throughout Placentia Bay.

1.4.4.1 Iceland Sites



Figure 26. Arnarlax Sea site (yellow markers) location in Iceland use Aqualine Midgard System. (<https://www.arnarlax.is/en/about-arnarlax/locations>)



Figure 27. Arnarlax's site, exposed directly to the North Sea – located in the outer part of the Westfjord Faroe Island Site.

1.4.4.2 Faroe Island Sites



Figure 28. Marine Harvest Faroe Island Sites (yellow markers).
(<http://marineharvest.fo/samband/samband-vio-marine-harvest-foroyar/>)



Figure 29. Marine Harvest sites located at the Faroe Islands.

From the Köppen climate classification, the overall climate of the Faroe Islands is influenced by the strong warming influence of the Atlantic Ocean, which produces the North Atlantic Current. This, together with the remoteness of any source of warm airflows, ensures that winters are mild while summers are cool. The islands are very windy, cloudy and cool throughout the year with an average of 210 rainy or snowy days per year. The Islands also lie in the path of depressions moving northeast, making strong winds and heavy rain possible at all times of the year (Faroe Islands.fo, 2018). Based on the climate information, the sea cage sites in the Faroe Islands are comparable to that of Placentia Bay but are exposed to significant higher waves than the proposed sites in Placentia Bay offers.

Compared to the significant wave heights for the proposed BMA in Placentia Bay (Table 3) these sites in Faroes using the Aqualine Midgard System are significant more exposed to wave heights than the actual proposed sites for Grieg NL in Placentia Bay.

Table 3. Wave height statistics for the Placentia Bay BMAs, 1954-2015 (Oceans 2018).

BMA	Range of Monthly Mean Significant Wave Height (m)	Range of Monthly Maximum Wave Height (m)	Range of Extreme Significant Wave Height for 50-yr Return Period (m)	Range of Extreme Maximum Wave Height for 50-yr Return Period (m)
Rushoon	0.7 to 1.6	3.7 to 7.8	6.1- to 7.3	11.0- to 13.2
Merasheen	0.2 to 1.4	1.3 to 7.2	2.1- to 6.8	4.0 to 12.2
Red Island	0.4 to 0.7	1.8 to 3.2	na	na
Long Harbour	0.2 to 1.9	1.3 to 7.9	2.2 to 5.0	4.2 to 9.0

1.4.4.3 UK Sites



Figure 30. Marine Harvest Scotland Seawater farms (yellow markers) use Aqualine Midgard System. (<https://www.mhsfeedplant.co.uk/original-proposal/>)

The climate of Scotland is temperate and oceanic, and tends to be very changeable, but not normally extreme. It is warmed by the Gulf Stream from the Atlantic and given its northerly latitude it is warmer than areas on similar latitudes, for example Labrador in Canada. Even though most of the country has a temperate climate, the Northern islands and Highlands experience a type of weather close to the climate of the Faroe Islands or Southern Norway. Scotland is the windiest country in Europe due to eastward moving Atlantic depressions that bring strong winds and clouds continuously throughout the year (Royal Meteorological Society 2017). Based on the climate information, the sea cage sites in Scotland are comparable to that of Placentia Bay.

1.4.4.4 Northern Norway

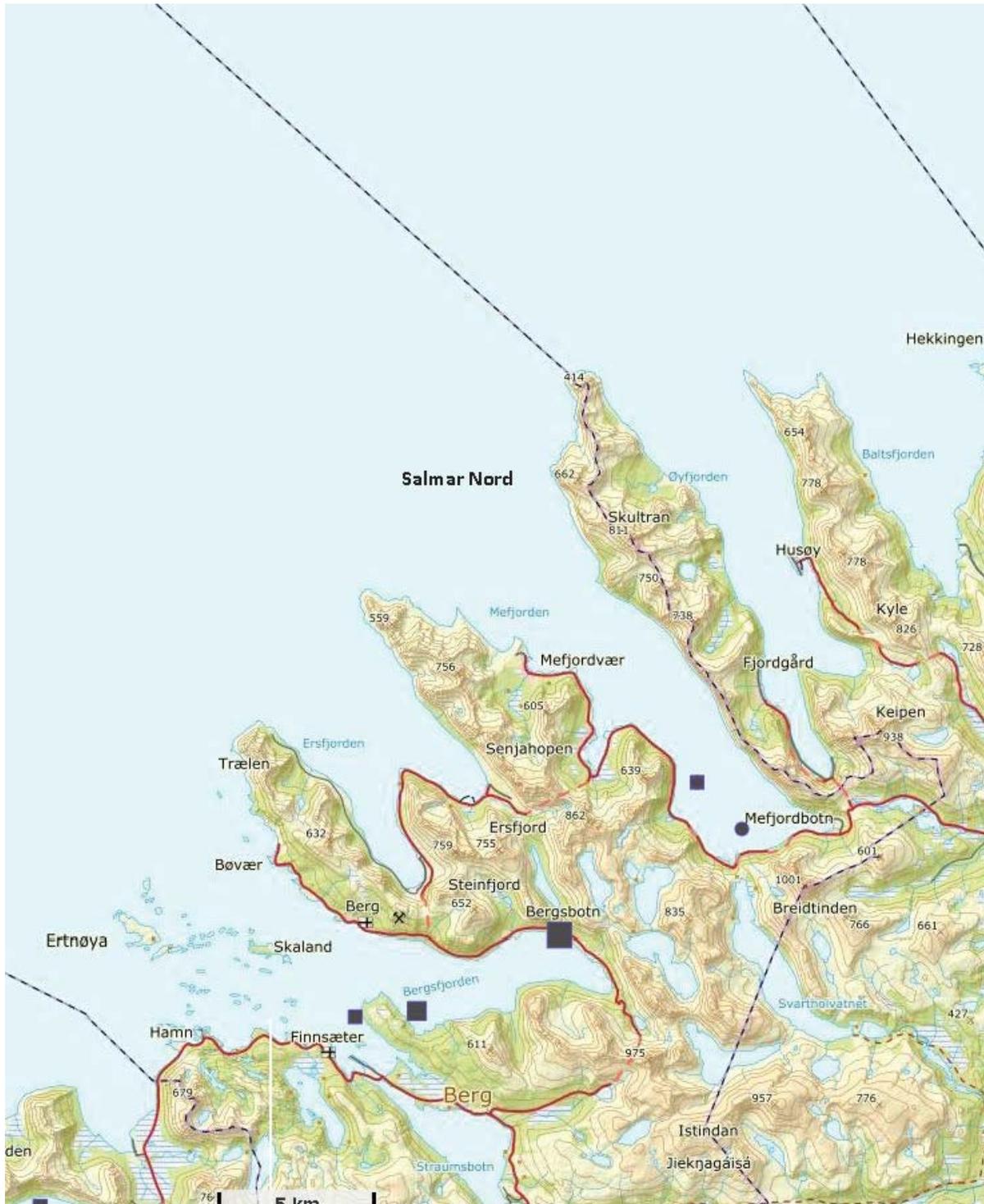


Figure 31. SalMar Nord in Norway use Aqualine Midgard System. (<http://aqualine.no/en/customers#791>)

Coastal regions of Northern Norway are typically free of ice all winter long due to the warming effects of the Gulf Stream, but low air temperatures (minus 10 -15°C) and gales are common. The region can experience rapid changes in both weather patterns and temperature during any season (Norwegian Meteorological Institute 2017). The sea cage sites located in Northern Norway are comparable to the proposed sea sites located throughout Placentia Bay.

Each delivery of Aqualine’s Midgard System is unique to the environment and conditions in which it is being placed. Since 2015, Aqualine, in cooperation with third-party companies such as AMEC Foster Wheeler (Appendix VII) and DHI (Appendix VIII), have completed studies at the proposed sea site locations in Placentia Bay. This allowed Aqualine to develop a site-specific Midgard system for Placentia Bay using the below process.

It is our position that the Aqualine Midgard Systems that are in use at multiple locations in Norway, Iceland, UK and Faroe Island in locations are similar to the proposed sites in Placentia Bay.

We have determined that the above procedures and accreditation ensures that the development and design for specific geographic locations proposed in Placentia Bay is done in a correct way based on the below environmental parameters. Specific design of the Aqualine Midgard System is dependant upon accurate environmental information collected at each site location.

Below is an overview of metocean conditions for the northern half of Placentia Bay in which the Aqualine Midgard System design for Grieg NL is based on. Data sources used to analyse precipitation, air temperature and wind speed and direction include the MSC50 Wind and Wave Reanalysis dataset, the National Hurricane Centre’s Tropical Storm dataset, two SmartBay buoys, and several ECCC Weather Stations located throughout area.

1.4.4.5 Climate and Meteorology

Typical of marine environments, climate conditions in Placentia Bay are influenced by its surrounding waters and the passage of high- and low-pressure circulation systems. Weather in marine regions generally includes cooler summers and milder winters than continental regions, with a smaller annual temperature range and overall more humid conditions. Increased humidity in marine regions results in reduced visibility (e.g., due to fog), low cloud heights and high precipitation. Monthly and annual minimum, maximum and mean values for precipitation, temperature and wind speed, along with prevailing wind direction and indications of recent climate change observations and trends in the Study Area are provided in subsections below. Where precipitation, air temperature and wind speed measurements were unavailable specifically within a BMA, data from nearby sources (e.g., weather stations and SmartBay buoys) were utilized (Oceans 2018).

Precipitation

Precipitation values were obtained from four ECCC climate stations in northern Placentia Bay: Red Harbour (west of the Rushoon BMA), Long Harbour (within the Long Harbour BMA), and Arnold’s Cove and Come by Chance (north of the Merasheen and Red Island BMAs). Monthly and annual minimum, maximum and mean precipitation values for the Rushoon, Merasheen, Red Island and Long Harbour BMAs are provided in Table 4. Mean annual precipitation values range from ~108-154 mm (minimum: 13 mm; maximum: 361 mm during a given month), with maximum daily precipitation values of ~108-199 mm for all four BMAs. The Rushoon BMA receives the greatest mean precipitation during a given month.

Table 4. Monthly and annual minimum (‘min’), maximum (‘max’) and mean precipitation values (mm) for the Rushoon, Merasheen, Red Island and Long Harbour BMAs. Location names in parentheses indicate representative ECCC climate stations. Values inclusive of all available data sources for each BMA.

Month	Rushoon BMA (Red Harbour)			Merashheen and Red Island BMAs (Come by Chance & Arnold’s Cove)			Long Harbour BMA (Long Harbour)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Jan	101.0	278.0	162.9	37.8	213.7	124.2	42.0	202.1	127.4
Feb	54.2	226.0	149.1	17.2	265.2	103.6	24.4	207.7	111.6
Mar	78.0	279.3	144.3	42.9	171.0	104.0	42.5	218.4	110.0
Apr	65.4	361.0	145.5	20.8	196.9	89.6	21.9	240.9	101.9
May	49.6	245.6	146.6	28.8	153.8	90.8	28.8	157.2	92.7
Jun	53.8	186.3	114.9	42.2	300.5	121.7	17.8	249.2	112.8
Jul	57.3	195.2	124.4	21.1	233.4	90.4	13.0	223.4	92.3
Aug	80.6	196.2	120.2	28.2	204.0	96.8	53.2	343.6	110.5
Sep	92.6	294.6	179.3	33.8	196.2	109.6	52.3	222.7	124.5
Oct	117.6	355.5	207.2	33.7	259.4	134.2	52.6	311.2	148.0
Nov	74.6	273.0	176.2	33.0	185.8	116.2	62.8	208.4	125.9
Dec	142.0	231.6	174.3	56.2	207.2	113.3	60.8	168.2	117.6
Annual	49.6	361.0	153.7	17.2	300.5	107.9	13.0	343.6	114.6

Air Temperature

Monthly and annual minimum, maximum and mean air temperature values for the Rushoon, Merasheen, Red Island and Long Harbour BMAs are provided in Table 5. The Marticot Harbour and Long Harbour ECCC climate stations are within the Rushoon and Long Harbour BMAs, respectively. Otherwise, the Red Harbour climate station is west of the Rushoon BMA, and the Argentia station is south of the Long Harbour BMA. There are no climate stations within the Merasheen or Red Island BMAs. The Come By Chance and Arnold’s Cove climate stations are north of these two BMAs. Air temperature is not expected to vary overmuch throughout the

northern Placentia Bay region on a given day. The mean annual air temperature for all four BMAs is ~5°C, with minimum and maximum temperature ranges of approximately -30 to 30°C.

Table 5. Monthly and annual minimum ('min'), maximum ('max') and mean air temperature values (°C) for the Rushoon, Merasheen, Red Island and Long Harbour BMAs. Location names in parentheses indicate representative ECCC climate stations. Values inclusive of all available data sources for each BMA.

Month	Rushoon BMA (Red Harbour & Marticot Harbour)			Merashen and Red Island BMAs (Come by Chance & Arnold's Cove)			Long Harbour BMA (Long Harbour & Argentina)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Jan	-24.5	12.0	-3.5	-25.6	11.0	-4.6	-24.0	15.1	-2.8
Feb	-28.5	9.0	-4.1	-28.9	14.5	-5.3	-25.0	16.0	-3.2
Mar	-22.0	12.5	-2.0	-25.0	15.0	-2.2	-22.5	17.2	-1.0
Apr	-17.0	17.0	2.1	-18.0	20.0	2.3	-14.0	21.0	2.6
May	-6.0	25.5	6.0	-8.0	20.0	6.0	-6.7	20.6	6.2
Jun	-2.0	26.0	10.2	-3.3	25.0	9.7	-5.0	25.0	10.0
Jul	0.0	28.5	14.3	1.0	27.5	14.0	-1.0	26.1	14.4
Aug	0.5	29.5	16.2	1.0	29.0	15.4	1.7	30.6	15.8
Sep	-1.5	30.0	13.1	-1.7	26.5	12.5	-2.5	27.0	13.0
Oct	-7.0	21.5	8.5	-8.0	23.0	7.7	-6.0	22.5	8.6
Nov	-14.0	17.5	4.1	-15.0	16.1	3.2	-12.0	21.1	4.6
Dec	-23.0	13.0	-0.6	-24.0	14.4	-1.7	-20.0	16.1	0.2
Annual	-28.5	30.0	5.4	-28.9	29.0	4.8	-25.0	30.6	5.7

Wind Speed and Direction

Monthly and annual minimum, maximum and mean wind speed values for the Rushoon, Merasheen and Long Harbour BMAs are provided in Table 6. Mean wind speeds are ~8 m/s (minimum 0.0 m/s; maximum ~30 m/s) or ~29 km/h (~16 kn) for all three BMAs. Wind speed and direction statistics are not available for the Red Island BMA due to lack of observations and modelled data in the area. Due to the proximity of the islands to the east and west of the Red Island BMA, prevailing winds would be north-northeast to south-southwest, with the islands occasionally serving as wind breaks, particularly for the Butler Island and Red Island proposed sea cage sites.

Table 6. Monthly and annual minimum ('min'), maximum ('max') and mean wind speed values (m/s) for the Rushoon, Merasheen and Long Harbour BMAs (data unavailable for the Red Island BMA). Values inclusive of all available data sources for each BMA.

Month	Rushoon BMA			Merashen BMA			Long Harbour BMA		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Jan	1.0	25.3	10.6	1.7	25.1	10.6	0.2	30.3	9.8
Feb	0.5	26.3	10.1	0.7	26.9	10.1	0.1	30.8	9.4
Mar	0.6	26.9	9.3	0.1	26.9	9.3	0.1	26.7	8.7
Apr	0.4	20.5	8.0	0.6	20.3	8.0	0.1	25.8	7.6
May	0.3	21.3	6.3	0.4	19.1	6.4	0.0	23.4	6.1
Jun	0.1	19.5	5.7	0.2	19.4	5.7	0.0	20.6	5.6
Jul	0.2	22.2	5.4	0.3	22.8	5.4	0.1	22.2	5.5
Aug	0.3	24.4	6.0	0.4	22.8	6.0	0.1	25.6	5.9
Sep	0.4	26.5	7.2	0.6	26.9	7.3	0.1	29.9	6.9
Oct	0.9	30.0	8.6	0.9	28.3	8.6	0.1	28.6	8.0
Nov	0.5	23.8	9.4	0.8	23.4	9.5	0.0	28.0	8.8
Dec	1.1	25.4	10.4	1.5	24.6	10.4	0.1	30.0	9.6
Annual	0.1	30.0	8.1	0.1	28.3	8.1	0.0	30.8	7.7

The prevailing wind direction in Placentia Bay is a southwest to west flow throughout the year. During the winter, west to northwest winds are prevalent, with a counter-clockwise shift beginning in March and April resulting in predominant southwest winds during the summer. The tropical-to-polar temperature gradient strengthens during the fall, returning to prevailing westerly winds by late-fall and into the winter.

Climate Change

The number of icebergs off Newfoundland and Labrador is positively correlated with the Labrador spring ice extent, with a decrease in the sea ice extent due to climate variability likely resulting in fewer icebergs near the proposed sea cage sites. Sea levels have been increasing on a global scale as a result of climate change, primarily due to thermal expansion and glacier melt. The rate of sea level change varies regionally, with some areas, generally those located near glaciers and ice sheets, experiencing a decrease in sea level while other regions observe a rise. A sea level rise of ~0.6 m is anticipated for the waters off southern Newfoundland and Labrador, including Placentia Bay, by the 2081-2100 period.

An overall decrease in pressure and a poleward shift in the jet stream at a rate of 0.17-0.19 degrees/decade occurred during 1979-2001, implying an increase in jet stream altitude in the Northern Hemisphere. These changes were consistent with an increase in mean equator-to-pole temperature. Altered jet stream strength, latitude and altitude may affect the formation and evolution of storms in the mid-latitudes and hurricanes in sub-tropical regions, as reflected in a significant decrease in mid-latitude and increase in high-latitude cyclone frequency during 1959-1997, consistent with increases in winter Northern Hemisphere temperatures.

Physical Environment

The Geologic Survey of Canada (GSC) and Canadian Hydrographic Service (CHS) conducted systematic mapping of Placentia Bay, Newfoundland and Labrador using multibeam sonar and surveyed with sub bottom profilers (Shaw et al. 2011). Interpretation of the multibeam data was supported by seismic data, side scan sonograms, bottom photographs, video, submersible observations and grab samples to generate a high-resolution seascape dataset (Shaw et al. 2011). The data was georeferenced spatially using GIS software and then digitized and coded. For each sea site the percentage represented by multibeam data is reported in Appendix VII, as is the percentage for each habitat type defined within.

The baseline site characterization data (Figure 32) was used to designate potential lease sites as hard bottom according to the Monitoring Protocol for Hard Bottom Benthic Substrates under Marine Finfish Farms in Newfoundland and Labrador (NL) under Annex 9 of the AAR (<http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-gd-eng.htm#annex9>) if “more than 50% of the lease area is hard bottom composed of rock wall, bedrock, boulders, rubble, cobble, gravel, or hard packed finer substrates” (DFO 2017b).

Lease areas with less than 90% multibeam survey coverage (Gallows Harbour, Long Island, Brine Island) were surveyed using drop video at 100 m grid intervals by Grieg NL personnel. The results from the video analysis were inputted following Annex 9, (Table 1. Substrate Type and Table 2. Benthic Descriptors) in the AAR regulations.

Ocean Currents

The near-surface currents in Placentia Bay flow in a counter-clockwise orientation (Figure 33.), although this circulation pattern is inconsistent at deeper water depths. The flow in Placentia Bay is influenced by the predominantly south-westerly winds, the Labrador Current, and, to a lesser extent, tides. The inshore branch of the Labrador Current follows the Avalon Peninsula’s bathymetric contours. The Labrador Current likely divides north of Green Bank, a portion of the Grand Banks south of Placentia Bay and east of the Halibut Channel, where the bathymetric contours shift from an east/west orientation to north/south, with a portion flowing into Placentia Bay and having a major influence on the overall current variability in the Study Area.

Figure 8 Butler Island Site

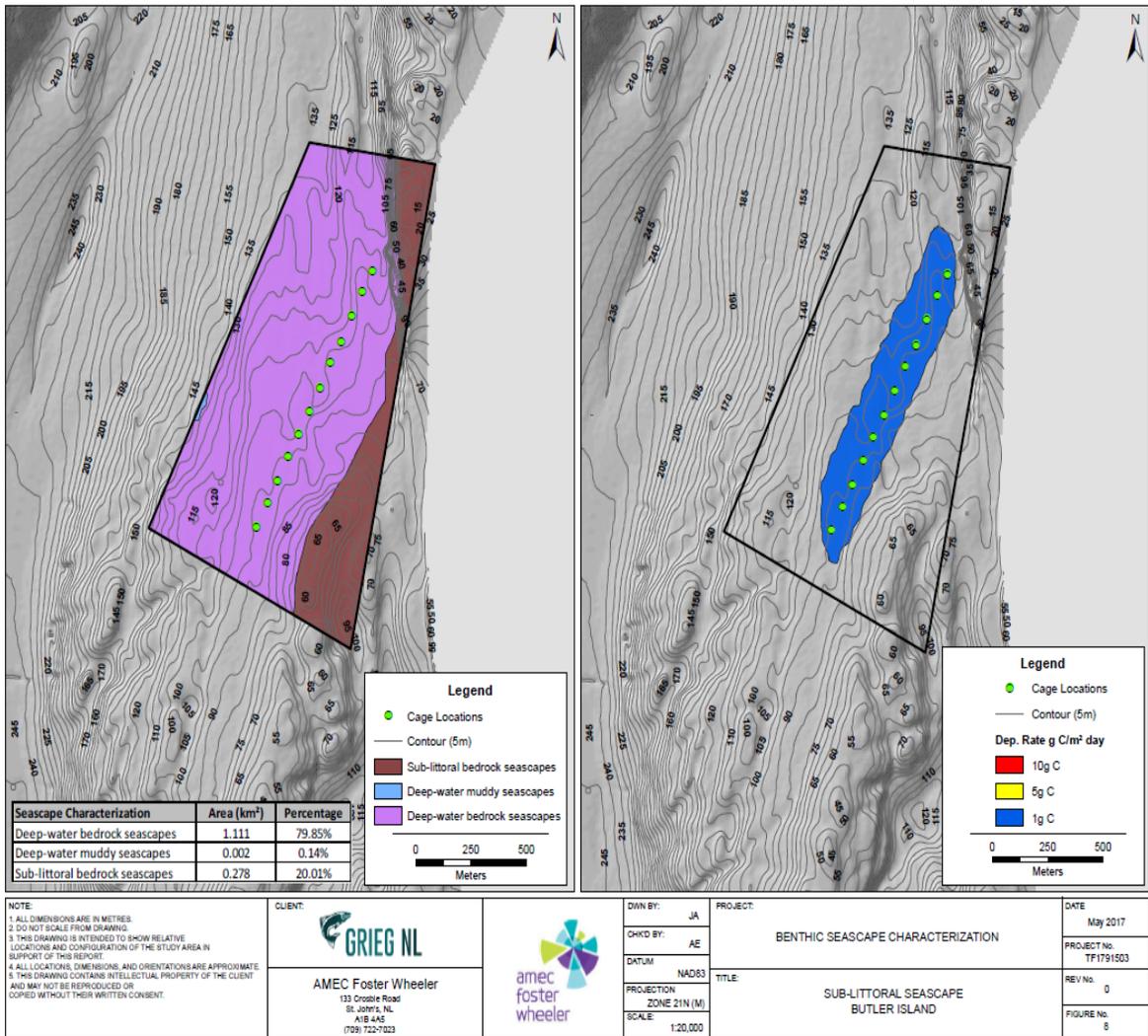


Figure 32. Benthic seascape characterization for the proposed Butler Island Site.

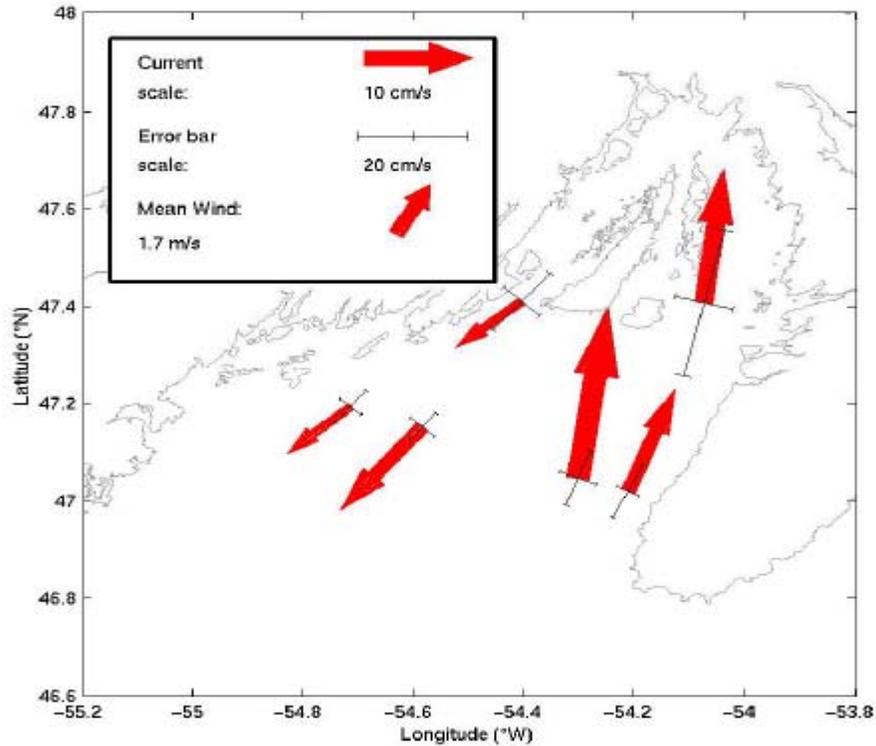


Figure 33. Movement of current throughout Placentia Bay, from analysis of the mean circulation in Placentia Bay: Spring and Summer 1999 (Schillinger et al. 2000).

Ocean current data was collected within and near the Rushoon, Merasheen, Red Island and Long Harbour BMAs by the Department of Physics and Physical Oceanography (Memorial University of Newfoundland and Labrador), the Bedford Institute of Oceanography, the Marine Institute School of Ocean Technology (via SmartBay Buoy), and DHI (Appendix VIII) for Grieg NL.

Mean, maximum and spring tide tidal current speeds for the four BMAs are presented in Table 7. Where data were available, the mean current speeds ranged from ~8-16 cm/s (~0.3-0.6 km/h or ~0.2-0.3 kn) for the BMAs, with a maximum speed of 79 cm/s (~3 km/h or ~2 kn). Spring tide tidal currents were 5-10 cm/s (~0.2-0.4 km/h or ~0.1-0.2 kn).

Table 7. Mean, maximum ('max'), and spring tide tidal current speed values (cm/s) for the Rushoon, Merasheen, Red Island and Long Harbour BMAs. Values inclusive of all available data sources for each BMA.

BMA	Location Relative to BMA	Depth (m)	Current Speed (cm/s)		Spring Tide Tidal Current (cm/s)
			Mean	Max	
Rushoon	South of BMA	20	10.3	49.7	8
	South of BMA	-	9.1	37.3	
	Proposed Sea Cage Site - Gallows Harbour	30	-	5	
	Proposed Sea Cage Site - Long Island	30	-	15	
	Proposed Sea Cage Site - Oderin Island	30	-	5	
Merasheen	North & South of BMA	36	7.9	36.5	5-6
	Proposed Sea Cage Site - Ship Island	30	-	30	
	Proposed Sea Cage Site - Chambers Island	30	-	14	
	Proposed Sea Cage Site - Valen Island	30	-	10	
Red Island	Proposed Sea Cage Sites	30	-	15	-
Long Harbour	Eastern Head of Placentia Bay	20	14.5	75	10
	Middle of Channel between Red Island & Long Harbour	16	16	79	
	Southwest of Long Harbour	23	12.5	75	
	Proposed Sea Cage Site - Brine Islands	30	-	25	
	Proposed Sea Cage Site - Iona Islands	30	-	25	

'-' Denotes data unavailable.

Wind and Wave Action

A sea state may be composed of a wind wave, swell, or a combination of a wind wave and one or more swells. The wave climate of Placentia Bay is dominated by extra-tropical storms, predominantly during October through March. The majority of wave energy travels from the west/south-southwest to the east/east-northeast in the Rushoon BMA, and the southwest to the northeast in the Merasheen and Long Harbour BMAs. Wave energy direction is not available for the Red Island BMA.

Wind climate data for 1954-2015 from the MSC50 North Atlantic wind and wave climatology database were analysed for the northern Placentia Bay area. Monthly and annual mean and maximum wave height values for the Rushoon, Merasheen, Red Island and Long Harbour BMAs are provided in Table 8. Wave height values for the Red Island BMA were modelled for a location north of Red Island. While not entirely representative of conditions near the proposed sea cage sites within the Red Island BMA, these values provide a better synopsis of conditions than data from the open Bay. Mean wave heights are approximately 1 m or less for the BMAs, with maximum wave heights of ~8 m.

Table 8. Monthly and annual mean and maximum ('max') wave height values (m) for the Rushoon, Merasheen, Red Island and Long Harbour BMAs. Values inclusive of all available data sources for each BMA.

Month	Rushoon BMA		Merashheen BMA		Red Island BMA ^a		Long Harbour BMA	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Jan	1.5	6.2	1.0	6.1	0.7	2.8	1.1	7.9
Feb	1.4	6.7	1.0	6.4	0.7	2.6	1.1	7.5
Mar	1.3	6.7	0.9	6.5	0.6	2.7	0.9	7.0
Apr	1.1	4.6	0.7	4.3	0.6	2.1	0.8	7.0
May	0.9	5.0	0.6	4.2	0.4	2.3	0.5	3.9
Jun	0.8	4.1	0.5	3.7	0.4	1.8	0.5	4.0
Jul	0.8	4.6	0.5	4.3	0.4	2.0	0.5	3.4
Aug	0.8	6.0	0.6	5.2	0.4	2.3	0.5	4.0
Sep	1.0	6.9	0.7	6.2	0.5	2.4	0.6	5.0
Oct	1.1	7.8	0.8	7.2	0.5	3.2	0.8	5.8
Nov	1.2	6.2	0.9	5.5	0.6	2.9	0.9	6.9
Dec	1.4	6.9	1.0	6.2	0.7	3.2	1.0	7.8
Annual	1.1	7.8	0.7	7.2	0.5	3.2	0.8	7.9

^a Significant wave height (i.e., the average height of the highest third of the waves; its value roughly approximates the characteristic height observed visually).

Extreme mean and maximum significant wave heights, such as those induced by storm events, were estimated based on probability for the Rushoon, Merasheen and Long Harbour BMAs for the next 100 years and are summarized in Table 9. Data were not available to perform an estimation for the Red Island BMA. Probable estimated extreme mean and maximum significant wave height values during 1-, 10-, 25-, 50- and 100-year periods are greatest for the Rushoon BMA, followed by the Merasheen and Long Harbour BMAs.

Table 9. Estimated mean and maximum ('max') extreme significant wave height values (m) for the Rushoon, Merasheen, and Long Harbour BMAs (data unavailable to estimate values for the Red Island BMA). Values inclusive of all available data sources for each BMA.

BMA	1-year		10-year		25-year		50-year		100-year	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Rushoon	4.8	9.5	6.0	11.7	6.4	12.5	6.7	13.2	7.1	13.8
Merashheen	3.1	8.6	3.9	10.7	4.2	11.6	4.5	12.2	4.7	12.9
Long Harbour	2.3	6.6	2.8	8.2	3.0	8.8	3.2	9.0	3.3	9.4

Storms

In addition to mid-latitude low pressure systems in the region, tropical cyclones often travel northwards toward Newfoundland and Labrador, beyond the influence of the warm waters of the Gulf Stream. The tropical cyclone season around Newfoundland and Labrador typically occurs from June to November, although cyclones may occur beyond this period. Once these cyclones move over cold, Newfoundland and Labrador waters, they lose their source of latent heat energy,

and typically begin to transition into a fast-moving, rapidly developing extratropical cyclone. An average 46% of tropical cyclones formed in the Atlantic transform into extratropical cyclones, resulting in an increase in size and producing large waves, gale- to hurricane-force winds and intense rainfall. The likelihood of a tropical cyclone transitioning into an extratropical cyclone increases during the latter half of Newfoundland and Labrador's tropical cyclone season, with the highest probability during October.

The number of tropical storms that have developed within the Atlantic Basin have increased during the last 19 years. This increase is attributed to naturally occurring cycles in tropical climate patterns near the equator, known as the 'tropical multi-decadal signal'. Despite this increase, there has not been a corresponding significant increase in the number of storms which have entered the Canadian Hurricane Response Zone or which have passed within 278 km (150 nm) of the BMAs. A subset of tropical cyclone climatology data (April-September 1960-2015) was analysed from the National Hurricane Centre's best-track dataset, obtained from the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Centre Historical Hurricane Tracks online database. Data were analysed for all storms within a 150-nm buffer zone of the Rushoon, Merasheen, Red Island or Long Harbour BMAs. Since 1960, 56 tropical systems passed within 150 nm of the BMAs. These tropical systems occurred during June to October, with most systems appearing during September. Few of these systems maintained hurricane strength, including three Category 1, one Category 2 and one Category 3 strength hurricanes. The most intense of these hurricanes was Hurricane Ella, which entered the area on 5 September 1978 with maximum sustained wind speeds of 54.0 m/s (~195 km/h or ~105 kn) and a central pressure of 960 mb.

Ice

During periods of lower than normal wintertime sea level pressure over the North Atlantic, the Labrador Sea ice boundary extends further south towards Newfoundland and Labrador during the spring. Placentia Bay is relatively ice-free compared to other bays surrounding Newfoundland and Labrador. Ice is only present in Placentia Bay from mid-February until mid-April, with the highest likelihood of ice presence during early-March. A weekly analysis the Canadian Ice Service database of 30-year (1981-2010) median ice concentration when ice is present in Placentia Bay indicated a median ice concentration of 9 to 9+/10ths within the Rushoon, Merasheen, Red Island and Long Harbour BMAs during the week beginning on 5 March (Figures 34 and 35). The frequency of sea ice presence within the BMAs during this period is 1-15% (Figure 36).

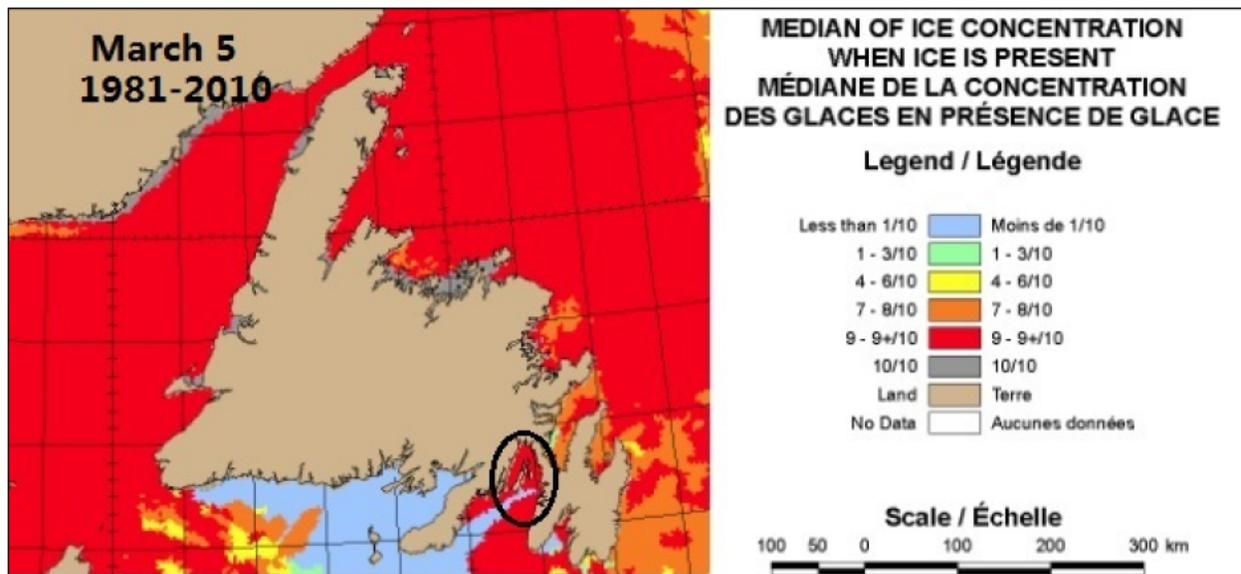


Figure 34. Median of ice concentration when ice is present for the week of 5 March, 1981-2010.

Source: Canadian Ice Service.

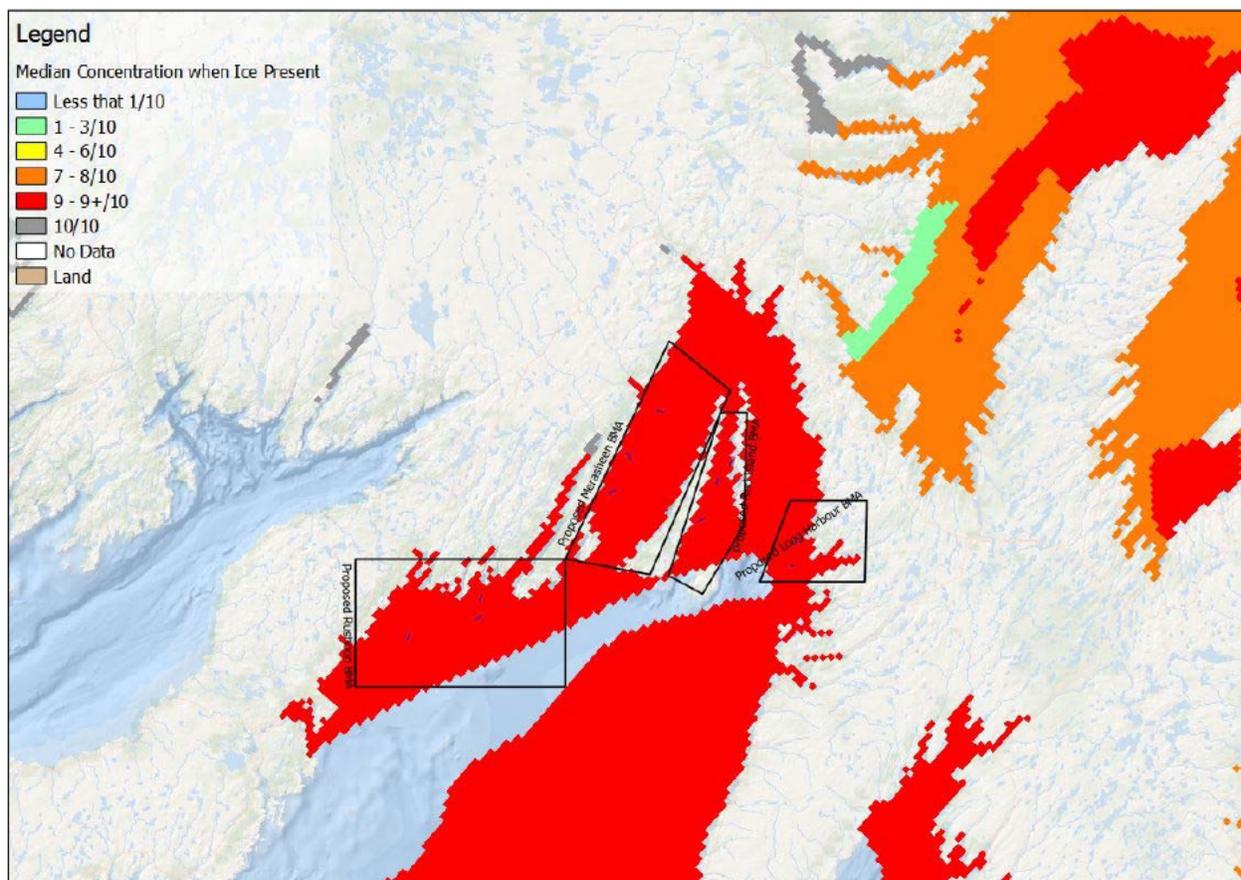


Figure 35. Median of ice concentration when ice is present for the Rushoon, Merasheen, Red Island and Long Harbour BMAs for the week of 5 March, 1981-2010.

Source: Canadian Ice Service.

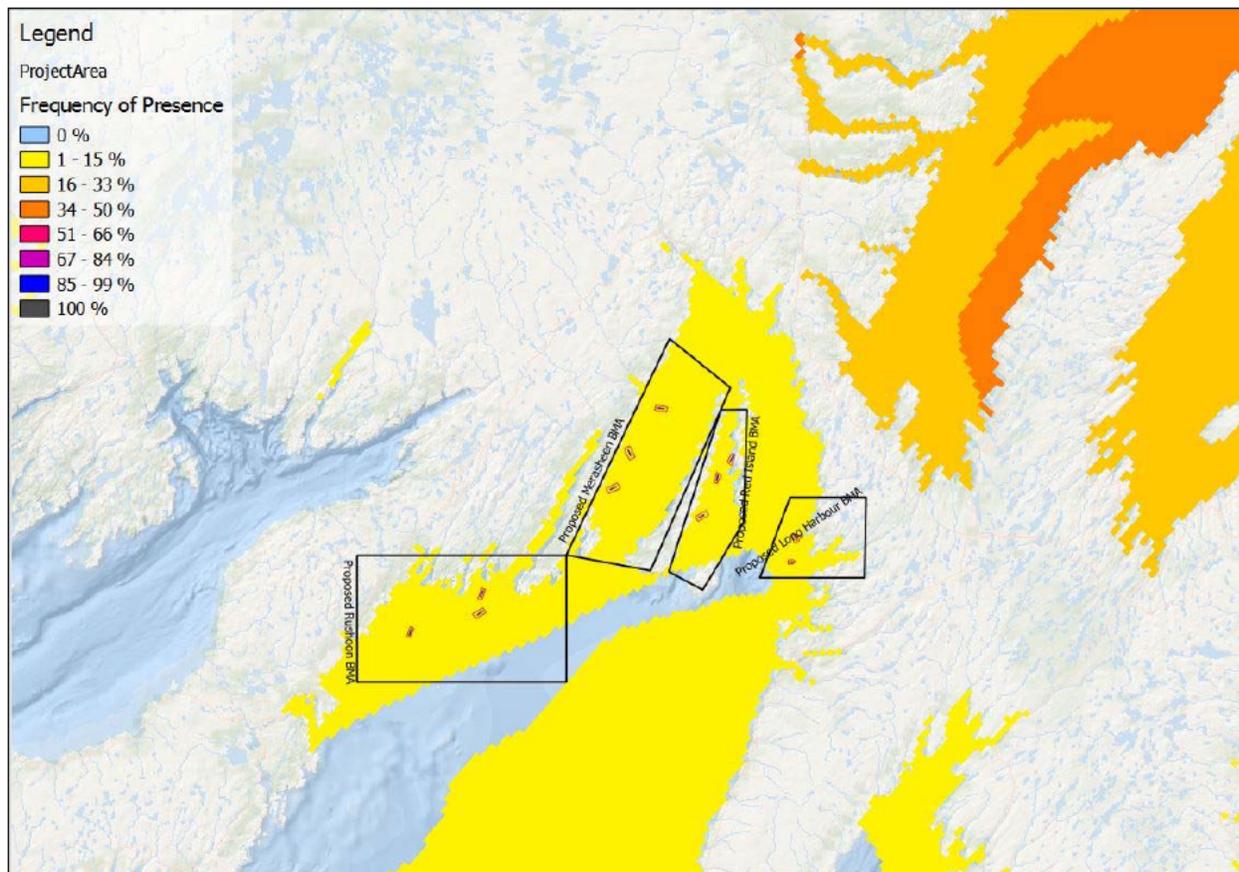


Figure 36. Frequency of ice presence for the Rusheen, Merasheen, Red Island and Long Harbour BMAs for the week of 5 March, 1981-2010.

Source: Canadian Ice Service.

Weekly sea ice charts for 2008-2017 for the northern half of Placentia Bay were analysed and summarized in terms of percent frequency of ice conditions for February to April, the months during which sea ice may be present in the Study Area (Table 10). Values provided are “worst case scenarios”; for example, if half of northern Placentia Bay was covered in 1/10th ice and half classified ice free, the value is provided as 1/10th for the whole northern Placentia Bay area. During 2008-2017, the concentration of the majority of sea ice was <1/10th (i.e., percent frequency of zero for ice concentration tenths 1 to 9+ during conditions of open water, bergy water or fast ice). An exception to the norm, the northern half of Placentia Bay contained 5/10ths coverage of sea ice during the week beginning 5 February during one year within 2008-2017. Open water conditions are prevalent from mid-February to mid-April. Bergy water and fast ice conditions begin during mid-March, with fast ice disappearing by the end of April.

Table 10. Percent frequency of weekly sea ice concentration for the northern half of Placentia Bay, February-April, 2008-2017.

Month	Week Start Date	Percent Frequency of Sea Ice Condition				Percent Frequency Tenths of Sea Ice Concentration									
		Ice Free	Open Water	Bergy Water	Fast Ice	1	2	3	4	5	6	7	8	9	9+
Feb	5	70	20	0	0	0	0	0	0	10	0	0	0	0	0
	12	40	50	0	0	0	10	0	0	0	0	0	0	0	0
	19	20	80	0	0	0	0	0	0	0	0	0	0	0	0
	26	30	70	0	0	0	0	0	0	0	0	0	0	0	0
Mar	5	40	60	0	0	0	0	0	0	0	0	0	0	0	0
	12	40	40	10	10	0	0	0	0	0	0	0	0	0	0
	19	50	20	0	20	0	10	0	0	0	0	0	0	0	0
	26	60	20	10	10	0	0	0	0	0	0	0	0	0	0
Apr	2	40	30	20	10	0	0	0	0	0	0	0	0	0	0
	9	40	40	10	10	0	0	0	0	0	0	0	0	0	0
	16	60	10	20	10	0	0	0	0	0	0	0	0	0	0
	23	60	10	10	10	0	10	0	0	0	0	0	0	0	0
	30	70	0	30	0	0	0	0	0	0	0	0	0	0	0

Ice Free = No ice present.

Open Water = Large area of freely navigable water in which ice is present in concentrations <1/10. No ice of land origin is present.

Bergy Water = Area of freely navigable water in which ice of land origin is present. Other ice types may be present, although the total concentration of all other ice is <1/10.

Fast Ice = Ice which forms and remains fast along the coast. May be attached to shore, ice wall/front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea level. Can extend to >100 km from the coast. May be >1-year-old. If >2 m above sea level, referred to as an “ice shelf”.

During 1960-2015, six icebergs of growler to medium-size were sighted within the four BMAs, three in Rushoon and one each within Merasheen, Red Island and Long Harbour. One of the icebergs sighted within the Rushoon BMA is of unknown size. None of these icebergs were within the immediate vicinity of the proposed sea cage sites, with the exception of a medium-sized berg near the Iona Islands proposed sea cage site in the Long Harbour BMA during 1996. Icebergs enter Placentia Bay from the Avalon Peninsula, with their presence and frequency dependent on factors such as iceberg concentration, ocean currents and wind.

1.4.5 Norwegian Technical Standard in Comparison to Current Containment Practices and Standards in Newfoundland and Labrador

Table 11 is a comparison of the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador to the Norwegian Technical Standard NS 9415:2009. This table is an overview of the requirements found in each document with a view to confirm the integrity of the Aqualine Midgard system in the Newfoundland and Labrador marine environment. For full

versions of the Newfoundland and Labrador Code of Containment for the Culture of Salmonids see Appendix V and Appendix II for the Norwegian Standard NS 9415.

Table 11. Comparison of current containment practices and standards in Norway and Newfoundland and Labrador confirming the integrity of the proposed system.

Norwegian Technical Standard (NS 9415)	Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (March 2014)
<p>Section 8 Requirements Regarding Net Pens</p> <p>8.1 General</p> <p>A net pen shall be suitable for the species it is to be used for.</p> <p>8.2 Relationship to the Floating Collar</p> <p>The net pen shall be suitable for the floating collar it is to be used in, and shall at a minimum have the number of attachment points to the floating collar in accordance with Table 10.</p> <p>8.3 Floating Collar Parameters</p> <p>All characteristics of the net pen which can be of significance to the floating collar and planning of it, shall be specified. Including:</p> <ul style="list-style-type: none"> -number and placing of all attachment points -maximum allowed forces in the attachment points -total weight of net pen -solidity <p>8.4 Requirements Regarding the Net Pen which is to be Used Together with the Stretching System</p> <p>8.5 Use of Environmental Parameters</p> <p>The calculations of the net pen shall at a minimum include a volume of fouling which gives up to 50% increase of the twine diameter in the net pen as a whole.</p> <p>The calculations of forces on the net pen caused by current shall include the dimensioning current velocity of the whole of the water column if no documentation is provided on varying current velocity at the relevant site. Net pens shall be calculated for the combination of environmental loads in accordance with Table 6.</p> <p>8.6 Dimensioning Principals</p> <ul style="list-style-type: none"> • Design working life in seawater • Determination of dimension grade • Determination of dimensioning requirements <p>8.7 Requirements for Design</p> <p>Net pens shall be made of twine and ropes which satisfy the following:</p> <ul style="list-style-type: none"> • Constructed in accordance with dimension grades stated • Assembled so that forces are transferred through ropes attached to twine and the rope shall have less elasticity than twine used • Lifting ropes shall tolerate the load when net pen is lifted • Net pen shall be produced without tears and inspected after production 	<p>Appendix 1 – Equipment Standards</p> <p>A1.1 Nets and Net Testing</p> <p>Design and Construction</p> <p>All nets shall be manufactured by suppliers whose designs meet or exceed standards referenced in this document (Net Testing Breaking Strength Tables 1 – 6).</p> <p>Nets shall be designed to perform in the conditions in which they are used (i.e., heavier mesh for sites of stronger current, etc.).</p> <p>Testing</p> <p>Nets over three years old and still in use should be tested every 18 months using the four (4) point stress test. This test shall be completed prior to stocking with fish. It is the responsibility of the growers to demonstrate that their nets have been tested.</p> <p>Responsibility of DFLR</p> <p>Ensure that growers have submitted annual net inventories and evidence of net testing prior to issuing transfer permits;</p> <p>Ensure that growers are performing diver net inspections every 90 days.</p> <p>Perform audits on a periodic basis to verify net testing, age of nets and diver net inspections.</p> <p>Responsibility of Industry Members</p> <p>Clearly tag all nets with a number;</p> <p>Keep an inventory of all nets in use.</p> <p>Provide proof of net purchase or manufacturer to verify net age in the event of lost tags, discrepancies or net age audit;</p> <p>Provide, prior to fish entry, an inventory of nets in use to DFLR and proof that nets have been tested.</p> <p>Provide evidence to DFLR of nets age upon request for nets less than three years of age. Failure to provide an inventory and evidence of net testing/age of net may result in DFLR’s refusal to issue transfer permits.</p> <p>Inspect nets via diver inspection every 90 days, document the dive and status of the nets, including any holes or repairs and retain copies on site for DFLR audit or inspection. If a dive cannot be performed at the specified interval, growers will fill out the dive report.</p>

Norwegian Technical Standard (NS 9415)	Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (March 2014)
<ul style="list-style-type: none"> • Splices shall not reduce strength significantly • Bottom shall be reinforced with double twine • Bottom shall be constructed so that it stands taut • Areas at the bottom shall be reinforced with double twine or equivalent. <p>8.8 Materials</p> <p>Materials shall be of such quality that they meet the requirements set out in this standard for filament, twine, fiber, and rope.</p> <p>8.9 Operation and Maintenance</p> <p>Inspection and repair of net pens: service cards that confirm that inspection and maintenance have been performed in accordance with the user handbook and that the net pen satisfies the requirement of NS 9415.</p> <p>Service cards have a validity of up to 24 months.</p> <p>8.10 Requirements for Documentation</p> <p>Documents of material quality, material use, dimensions, production, and repair of each net pen shall be in accordance with the standard's provisions and shall be stored for any subsequent inspection and documentation.</p> <p>At a minimum the following shall be documented:</p> <ul style="list-style-type: none"> • Assembly sketch of net pen • All allowed net designs, sizes, mooring lines • Twine number, mesh length, mesh type, and size of mesh • Description of any redundancies 	<p>A1.3 Mesh Size</p> <p>Fish shall be placed in nets of the appropriate industry standard mesh size – i.e., one-third (1/3) the size of the widest part of the fish body. Current industry standards are:</p> <ul style="list-style-type: none"> 1 1/8" stretch mesh (min. size 50g) 2¼" stretch mesh (min. size 450g) <p>These guidelines exceed the minimum size retained per mesh size as determined in "Determination of the Appropriate Cage Mesh Size for Retention of Salmonid Juveniles" by Memorial University of Newfoundland's Marine Institute in March 2000.</p>
<p>Section 9 Requirements Regarding the Floating Collar</p> <p>9.2 Planning</p> <p>Floating collars shall be dimensioned in accordance with planning of main components and composition of marine fish farms</p> <p>9.3 Mooring Parameters</p> <p>All characteristics of the floating collar which can be relevant to mooring and planning of it, shall be specified</p> <ul style="list-style-type: none"> • Requirement regarding pre-tensioning • Number and placing of all attachment points • Maximum force and three-dimensional; direction for relevant points • Maximum allowed moment from moorings <p>9.4 Net Parameters</p> <p>All characteristics of the floating collar which can be relevant to the net pen and planning of it, shall be specified</p> <ul style="list-style-type: none"> • Number of net suspension points for the stretching system with placing, capacity, and specification • Load effects from the net pen • Greatest total net weights • How fouling is taken into consideration when forces on the net pen are calculated 	<p>A1.2 Cages</p> <p>All cages shall be of proven design and construction. Plastic Circles and Hercules steel systems are in use worldwide. The design of cages used in Newfoundland and Labrador is based on the plastic circle design that is widely used throughout New Brunswick and British Columbia.</p> <p>All new cage system designs shall have a written documentation from the manufacturer outlining construction materials, strength of the system, and information regarding the environment in which the system has been successfully deployed. This information must be available prior to new fish entry to these systems.</p> <p>Plastic cages and Hercules systems are design for and used in open coastal waters worldwide.</p> <p>All nets are to be secured to the cage collar at every down line with minimum ½" polypropylene rope or rope of equivalent strength as illustrated in the table below. This will be verified by site visits during audits and seasonal inspections. Net weights will be hung and weighted in a manner that minimizes chaffing.</p>

Norwegian Technical Standard (NS 9415)	Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (March 2014)
<p>9.5 Requirements Regarding Floating Collars which are used Together with Stretching System</p> <ul style="list-style-type: none"> • Be suitable for the stretching system is it to be used with. <p>9.6 Requirement Regarding Construction Parts</p> <p>The floating collar shall be constructed such that:</p> <ul style="list-style-type: none"> • It is simple to install net pen and bird net • No chafing on the net pen • Easy to keep clean • Easy to keep clean in seawater • Easy to install extra equipment • No hollows where liquids can collect <p>9.7 Requirements Relating to Welds and Welder</p> <p>All welds shall be performed in accordance with approved procedures as in ISO 15607 and ISO 15614-1, ISO 15609, and ISO 15614-2.</p> <p>9.8 Installation and Repair</p> <p>Correct and suitable welding equipment shall be used.</p> <p>9.9 Specification of floating collar for towing</p> <ul style="list-style-type: none"> • Plan for attachment of towing hawsers and auxiliary system for towing • Maximum towing velocity and allowed wave and wind loads • Controls that damage has not occurred <p>9.10 Special Requirements for Steel Installations</p> <p>Strength calculation</p> <ul style="list-style-type: none"> • Global strength analysis • Local strength analysis • Fatigue analysis <p>Materials</p> <ul style="list-style-type: none"> • Breaking strength • Fatigue limit • Accident limit <p>9.11 Special Requirements for Flexible Marine Fish Farms</p> <ul style="list-style-type: none"> • The capacity of plastic pipe shall be regarded as exceeded if flow occurs in the cross section • Local cracking occurs in the cross section • Calculation of strength of the plastic installation • Dimensioning of the plastic against fatigue • All use of polyethylene shall be in accordance with NS-EN 12201-2 	

Norwegian Technical Standard (NS 9415)	Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (March 2014)
<p>9.14 Requirements Regarding Documentation</p> <p>At a minimum the following documentation shall be available:</p> <ul style="list-style-type: none"> • Assembly sketch of the floating collar • Specification of which functional requirements shall be met • Description of any redundancies • Description of environmental loads which the floating collar shall tolerate, at a minimum load from wind, current, waves, temperature, ice and snow. • Description of the permanent loads on the floating collar in the form of weight and the distribution of them on the collar • Description of accidental loads • Maximum weight and distribution of ice • Description of mooring system • Design working life • All floating collars shall be supplied with an identification plate • After assembly is complete, an assembly log shall be kept and confirms it has been performed in accordance with NS 9415 	
<p>Section 11. Requirements for Mooring</p> <p>11.2 Planning and Production</p> <p>A mooring shall keep marine fish farm in the correct position and in a three-dimensional position.</p> <p>The starting point for the requirements for the mooring shall be the dimensioning values given in site surveys.</p> <p>Mooring systems shall be dimensioned to:</p> <ul style="list-style-type: none"> • Tolerate all expected loads and deformations with satisfactory safeguarding against breaking • Function satisfactorily based on the environmental conditions at the locality • Sufficiently safeguarded against unforeseen events • Sufficient durability against destructive effects of a mechanical, chemical, physical or biological nature. <p>11.3 Requirements for Construction Parts</p> <p>Chains</p> <ul style="list-style-type: none"> • Choice of chains shall take place on requirements for strength in relation to the mooring calculation <p>Shackles</p> <ul style="list-style-type: none"> • Shall meet the requirements stated in NS-EN 13889 <p>Connecting elements</p> <ul style="list-style-type: none"> • Sufficient strength can be documented for the area of use in the mooring system <p>Anchors</p> <ul style="list-style-type: none"> • Shall be based through charting of the bottom conditions at the sites 	<p>A1.4 Mooring</p> <p>Failure of Mooring systems has not been recognized as a major cause of escapement in Newfoundland and Labrador. Mooring systems in Newfoundland and Labrador vary from site to site.</p> <p>Some mooring designs are consistent with mooring designs found in Norway for fjord settings, considering deep water, rock shorelines and currents associated with fjord hydrography. Other systems are sunken “grid” systems with proven performance in New Brunswick Nova Scotia and here in Newfoundland and Labrador.</p> <p>Growers will be required to submit a “Mooring Maintenance/Replacement Plan”, annually for each site that will be occupied with fish.</p>

Norwegian Technical Standard (NS 9415)	Code of Containment for the Culture of Salmonids in Newfoundland and Labrador (March 2014)
<p>11.4 Materials</p> <p>The materials shall be in accordance with the documentation from the supplier. These shall state producer, trade name, material type, characteristics, and marking of the product.</p> <p>11.5 Corrosion</p> <p>Regarding mooring parts of steel that are not inspected annually, thickness shall be expected to decrease by 0.4mm per year between each inspection.</p> <p>11.6 Fatigue</p> <p>Fatigue is dependant on load variations over time. Consideration shall be paid to loads which vary with wave frequency.</p> <p>11.9 Requirements for Laying Out and After-Inspection</p> <p>Laying out shall take place in accordance with a laying out plan. After the mooring is laid out, the requirements in the mooring calculations shall be controlled for compliance. In the case of significant deviation in positions and depths in relation to the calculation which have been used as the basis of the laying out plan, it shall be verified that the change has not led to significant weakening of the mooring.</p> <p>11.10 Requirement for Documentation</p> <ul style="list-style-type: none"> • Sketch showing measurements of the mooring site shall be available. • Specification of each anchor or bottom attachment shall be available. • A documented assessment shall be available of the impact of accidental loads such as unequal loads because of a break in the mooring line • Documentation of the mooring system shall give a description which is good enough to be able to assess/recalculate the moorings. 	<p>Appendix 4 – System Inspections</p> <p>Industry members shall formally monitor and inspect surface components of mooring systems, cages, nets and ropes on each site once per week and record the inspection on Form A.4. Inspection forms will be retained for audit and inspection on site by DFA staff.</p> <p>Industry members agree to comply with inspections of cages systems and mooring systems at the discretion of DFA or DFO. Audits will be conducted by DFA at a minimum of twice yearly (one audit in the spring, after fish entries; one audit in the fall/early winter) with at least 1-week advance notice to the operator so that site inspection records can be either sent to the DFA or sent to site for examination by DFA inspectors. Inspectors conducting the audits/inspection will use Form A.5 and will examine copies of all site inspections performed by site employees on the site. Copies of the form will be provided to the site owner, DFO and DFA.</p> <p>The owner shall repair any identified damage to site equipment immediately.</p>

1.4.5.1 Newfoundland and Labrador Salmonid Code of Containment

As seen in Table 11, Comparison of Current Containment Practices and Standards in Norway and Newfoundland and Labrador, as well as in Appendix V, Cages of the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador:

- The design of cages used in Newfoundland and Labrador are based on the **plastic circle design** that is widely used throughout New Brunswick and British Columbia.

The Aqualine Midgard System follows the above-mentioned plastic circle design. The Aqualine Midgard System uses polyethylene plastic for the circular floating collar construction (see Appendix III). Also, these systems are deployed in open coastal waters world wide including Canada (British Columbia).

- **New cage systems** shall have written documentation from the manufacturer outlining construction materials, strength of the system, and information regarding the environment in which the system has been successfully deployed.

All Aqualine Midgard floating collars are certified by DNV GL (Appendix IV.B) according to requirements stated in the Norwegian regulation NYTEK (FOR-2011-08-16-849) and the Norwegian standard NS 9415. SINTEF completed scale model testing of the Midgard System (Appendix IV.A) to study the behaviour of the system in various wave and current conditions. All construction materials are in accordance to NS 9415 (as seen in Table 11), which cover material specifications, design approach with respect to analyses methods and testing, material and load factors, net specifications, and environmental specifications. The Aqualine Midgard System has been successfully deployed in countries world wide (Section 1.4.4) such as Iceland, Faroe Islands, Scotland, and Norway. According to the Norwegian Directorate of Fisheries, the number of escapes has decreased considerably (see Figure 12.) since 2014, when the Aqualine Midgard System became commercially available. This documentation satisfies the requirements outlined in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for “all new cage system designs” as well as the “information being available prior to new fish entry into these systems”.

1.4.6 Final Analysis and Evaluation of the Aqualine Midgard System

- *A summary of the successes, failures, and lessons learned from Midgard cage system installations at marine aquaculture sites in northern environments;*

During our review it was recognized that from the late 1960s to early-2000s most equipment used in the aquaculture industry was not standardized. During the mid-2000s the aquaculture industry in Norway moved from a non-controlled non-monitored industry to the implementation of a high-level standard and controlled fabrication process.

Through our review we are convinced, based on the number of Aqualine Midgard Systems sold to the industry worldwide since 2013, including some of the world leading salmon farming companies, the proclaimed ability of the Aqualine Midgard System has been confirmed by these users. There are no reports of major failures of the system and no reported escapes as discussed above. Some of the locations where the Aqualine Midgard System is being used, it is operating in areas as equally or more exposed and harsh as the proposed sites in Placentia Bay.

- *Methods and results of structural and operational tests conducted for, or collected by, the panel of experts on the Midgard cage system, and a synopsis of test results and conclusions for any previous structural and operational tests conducted on the cage system;*

We have determined that the SINTEF Ocean Research Center has proven their credibility through decades of development and testing of products for the marine environment (see <https://www.sintef.no/en/> and Appendix IV.C). Their focus on exposed aquaculture structures,

the use of this knowledge base, as well as their engineering capacity ensures the high-end quality of procedures and development for the Aqualine Midgard System. The detailed documentation of the system, the approval of the quality from the aquaculture industry, and the many certifications and standards the design is built on, ensures that the Aqualine Midgard System meets the standards in Newfoundland and Labrador for plastic circle cage systems as stated in the Code of Containment for the Culture of Salmonids (Appendix 5).

We have also determined that DNV GL with its certification of these cages furthermore ensures that the Aqualine Midgard System meets both international standards for fish farming cage systems as well as the available standards for fish farming cages in Newfoundland and Labrador.

The advancement in the components contained within the Aqualine Midgard System design, which are based on actual environmental conditions, allows Aqualine to adjust the design of the Aqualine Midgard System to meet each client's specific environmental needs. After delivering and having more than 1000 units in operation which hold more than 100 million salmon per generation in the system, creates a level of precision and quality that has given Aqualine the privilege of having non-reported escapes or major failure on their Aqualine Midgard System.

- *The application of oceanographic and meteorological data, including past sea-ice events, to predict the performance of the sea cages in the study area;*

We have determined that the aforementioned procedures and accreditation ensures that the development and design for specific geographic locations proposed in Placentia Bay are done in a correct manner based on known environmental parameters. Specific design of the Aqualine Midgard System is dependant upon accurate environmental information collected at each site location.

It is our position that the Aqualine Midgard Systems that are in use at multiple locations in Norway, Iceland, UK and Faroe Island in locations are similar to the proposed sites in Placentia Bay.

- *A description of the proposed Aqualine Midgard System, which has been designed against a Norwegian technical standard that has been viewed as effective at reducing escape incident rates in other jurisdictions;*

We have determined that the Aqualine Midgard System as described in this component study provides the industry with a cage system that significantly reduces the potential of escapes from aquaculture operations. As stated in the review, the Aqualine Midgard System among others was chosen by some of the applicants for green licenses in Norway due to the requirement of reduction of risk of escapes.

After delivering and having more than 1000 units in operation without any escapes or serious incidences the Aqualine Midgard System has clearly reduced the potential for escapes within the farming industry.

The design standards that Aqualine has built the Midgard System on covers design processes, material, production and deployment. They have built their risk analyses, design, dimensioning, production, installation and operation procedures based on the Norwegian Standard NS 9415. Since environmental conditions may have an impact on marine construction, Aqualine includes in their design for the Aqualine Midgard System, site specific environmental conditions. Aqualine has in-house the accreditation necessary for these kind of technical assessments (see Appendix IV) and they use internationally accepted companies offering environmental services for gathering reliable information from each local site the Aqualine Midgard System is being designed for. Compared to the information available in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador, we have determined that the Aqualine Midgard System meets all these requirements.

- *Evaluation of the Norwegian technical standard in comparison to current containment practices and standards in Newfoundland and Labrador, with a view to confirming the integrity of the proposed system in the Newfoundland marine environment.*

All Aqualine Midgard floating collars are certified by DNV GL (see Appendix IV.B) according to requirements stated in the Norwegian regulation NYTEK and the Norwegian standard NS 9415. All construction materials are in accordance to NS 9415, which covers material specifications, design approach with respect to analyses methods and testing, material and load factors, net specifications, and environmental specifications. The Aqualine Midgard System has been successfully deployed in countries worldwide such as Iceland, Faroe Islands, Scotland, and Norway which all have comparable climate to that of Placentia Bay. This documentation satisfies the requirements outlined in the Code of Containment for the Culture of Salmonids in Newfoundland and Labrador for “all new cage system designs” as well as the “information being available prior to new fish entry into these systems”.

1.4.7 Closing Remarks

We have determined that the Aqualine Midgard System is ideally suited for Placentia Bay waters. In our review, it was found that the compliance to the Norwegian Standard NS 9415 and the uniformity of process confirmed by DNV GL, allowed the Aqualine Midgard System to build on and enhance the conventional model of round plastic cages into a modern industrial standard system for use in the aquaculture industry.

After reviewing the documentations and information available for the Aqualine Midgard System and comparing it to the existing description of cage system for Newfoundland and Labrador, we have determined that the Aqualine Midgard System meets Provincial standards and regulations.

We have also determined that the system as designed is an optimal system for the Placentia Bay Atlantic Salmon Aquaculture Project. This system will allow the aquaculture industry to advance in a safe and sustainable manner and raise the benchmark on what Newfoundland and Labrador standards should strive to achieve.

2.0 References

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Personal Communication

Soreide, M., CTO, Aqualine, April 23, 2018

Appendices to Component Study - Aqualine Midgard Sea-Cage Study

- Appendix I – Panel of Experts
- Appendix II – Norwegian Standard NS 9415
- Appendix III – Aqualine User Manual – Aqualine Froya Ring Floating Collar
- Appendix IV.A – SINTEF Model Tests
- Appendix IV.B – DNV GL Certification
- Appendix IV.C – SINTEF Collaboration with Marine Institute
- Appendix IV.D – Accreditation Scope of INSP 036
- Appendix IV.E – AON Certification Letter
- Appendix V – Code of Containment for the Culture of Salmonids in Newfoundland and Labrador, March 2014
- Appendix VI – Plastic Pipe Institute – Recommended Minimum Training Guidelines
- Appendix VII – AMEC Final Benthic
- Appendix VIII – DHI Report – Grieg Seafarms, Newfoundland, Hydrographic Surveys, March 2016

Appendix I
Panel of Experts



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April 24, 2018

Ms. Joanne Sweeney
EIS Committee Chair
Dept. of Municipal Affairs and Environment

Revised: Aqualine Midgard Sea Cage Study Independent Panel of Experts

Dear Ms. Sweeney,

In addition to the document submitted on April 19, 2018, the proponent has received confirmation from DNV GL indicating their participation in the independent panel of experts. To meet the requirements set out in the Environmental Impact Statement Guidelines, the proponent gathered an independent panel of experts that are experienced in the marine, aquaculture, and industrial industries.

The proponent has assembled the group of experts listed below and presented the task as described in the Environmental Impact Statement Guidelines in which they agreed to undertake the Aqualine Midgard Sea Cage Component Study.

The review panel is comprised of Newfoundland and Labrador companies and individuals who have extensive experience with the use of structural and operational components which comprise the Aqualine Midgard System. The local panel of experts have advised that they are planning to reach out to external resources both locally and internationally which they feel are needed for complementing the component study. These external resources will be used for documentation purposes only.

We trust that this independent panel of local experts meets the level of expertise as required by the EIS committee.

Confirmed by,

A handwritten signature in blue ink that reads "Knut Skeidsvoll". The signature is written in a cursive style and is positioned above a horizontal line.

Knut Skeidsvoll
General Manager
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DNV GL

DNV GL is a global quality assurance and risk management company with an office based in St. John's NL. Providing classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. DNV GL also provides certification, supply chain and data management services to customers across a wide range of industries. Combining technical, digital and operational expertise, risk methodology and in-depth industry knowledge, empowering customers' decisions and actions with trust and confidence.

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Richard Kennedy

Richard Kennedy is the Station Manager of DNV GL St. John's responsible for managing ships in operation and offshore units in operation activities. He is a Professional Engineer and holds a Bachelor of Engineering in Ocean and Naval Architecture Degree from Memorial University and is a Principle Surveyor at DNV GL. He has been working in the shipping and offshore industries for over 20 years and has much experience in MODU, FPSO and Supply Boat Newbuilds, Conversions, and in Operation Activities. Has overseen large construction projects such as the SeaRose FPSO Newbuild project. He has also been involved in certification and verification of equipment within the shipping and offshore industries from design review, fabrication, inspection, commissioning and testing, through to final certification. Richard grew up in the fishing industry where he developed a love for the ocean which prepared him for working in the shipping and offshore industries. His primary focus is to carry out work that will safeguard life, property and the environment.

Keith Downey

Keith Downey is a Principle Survey, Auditor, and Flag Liaison Officer based in the DNV GL St. John's Station. He is a Professional Engineer and holds a Bachelor of Engineering in Ocean and Naval Architecture Degree from Memorial University. He has been working in the shipping and offshore industries for 15 years, with the past 10 years working for Classification Societies on the certification of ships and offshore units in operation, including product certification. As Flag Liaison Officer for Canada, Keith is responsible for liaison between Transport Canada and DNV GL with respect to all flag state inquiries including vessel safety and environmental protection. Prior to DNV GL he was working in the field of commercial marine research and development for a variety of vessel types and marine structures.



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Spence Corrosion Canada Inc.

Spence Corrosion offers an innovative approach to problem solving and solution development. Offering a comprehensive suite of services, Spence Corrosion can complement existing contractors by providing expertise in specialty piping and tanks that will ensure selection of the proper product to meet industries needs while being able to offer services of coatings or linings on any product. In addition to this line of services, Spence Corrosion inspection and maintenance services will help give peace of mind to ensure that your business operates at optimal performance with scheduled preventative maintenance and emergency repair services.

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Gerry Sullivan

Gerry Sullivan has been working with Spence Corrosion Canada looking at innovation and research for alternative high-quality procedures and products to advance traditional products in various sectors from mining to oil and gas to aquaculture. Prior to joining the Spence team, he has worked on project and risk management for over 15 years in the areas of protocol implementation, project planning and quality assurance. Working four years at Memorial University in a senior executive office, Gerry provided project management with a focus in logistics planning, and training. Most recently working with an industrial services company in the role of Business Optimization and Research Manager, Gerry worked with in all areas of the company looking at process flow and control as well for the last three years leading the research department in NDT Technologies and corrosion effects on product fabrication in the Atlantic Canada Environment. Gerry is currently the Operations Manager bringing a unique mix of experience and technical knowledge to the position.



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Norm Spence

Since the Completion of Post-Secondary Education at Simon Frasier University, Norm Spence has been an entrepreneur with a keen sense for identifying gaps in markets and being able to provide the services to fulfil that need. Leading the team at Spence Corrosion with over 25 years in business management Norm has succeeded by staying ahead of technology and always understanding all aspects of the services and lines of business that he offers to his clients.

Demonstrated through attaining NACE level 3 certification (#18132) and NACE Sr. Corrosion Technologist (#26199), Norm is a leader in coating and specialty services in various sectors including oil and gas with a skillset and knowledge base transferable to almost all sectors including the marine and aquaculture sectors. Spending a substantial portion of his early career working in the Aquaculture industry in British Columbia. Norm was able to foster a greater understanding of the market demands and the high level of precision and skill required to operate in the industry.



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Engineered Pipe Group

The Engineered Pipe Group (EPG) offers industry leading HDPE fusion training in the various methods of fusion including:

- butt fusion (including datalogger training if specified and on McElroy brand fusion equipment)
- electrofusion – various equipment & coupling manufacturers including Tega, +GF+, Plasson to name a few.
- inspector training courses.

Our training experts will train your personnel in the latest ASTM and other applicable standards via the Plastic Pipe Institute procedures to ensure the skills developed result in a safe work environment and the most efficient use of equipment and resources.

Whether your requirements are small diameter geothermal applications up to large Mega mining/industrial applications let EPG's industry leading fusion experts work with your team. Courses are available at any of our locations, your location or on the jobsite and they can be customized to your own unique applications or equipment.

Fusion certificates, reference literature & relevant mobile apps come with EPG fusion training to ensure you technicians have the resources they need moving forward.

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Steve Fleming

Steve Fleming is the Account Manager for the Engineered Pipe Group a distribution firm that specializes in high density polyethylene pipes valves & fittings, fusion equipment rentals and fusion training to the industrial and municipal markets.

His list of clients includes:

- Vale Long Harbour
- Exxon Mobil Hebron builder Kiewit Kvaerner Contractors
- Rio Tinto's Iron Ore Company of Canada
- Husky White Rose builder SNC Lavalin Dragados Pennecon
- City of St John's
- Spence Corrosion Services

Before devoting his work fulltime to the Engineered Pipe Group, Steve worked in sales in the consumer-packaged goods industry where he honed his skills at managing budgets and developing customer relationships and won numerous awards for sales growth.

Brian Parker

Brian Parker is the Sales Manager for the Engineered Pipe Group (EPG) in Atlantic Canada. EPG is a distribution firm that specializes in high density polyethylene pipes, valves & fittings, fusion equipment rentals and fusion training to the industrial and municipal markets.

Brian's technical background has enabled him to excel in his 13 years with EPG. It has helped him develop engineering relationships to specify the technical aspects of HDPE pipe fusion and real-world implementation of HDPE piping systems. Along the way he has set annual company HDPE sales records in the process and win the EPG branch manager of the year award for all Canada.

Some of Brian's customers and projects include:

- Saint John Safe Drinking Water project
- Amec / Piccadilly Potash Mines
- Nova Scotia Power Commission
- WSP Salt Caverns project



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Anthony Parker

Anthony is in Technical Sales Development for the Engineered Pipe Group (EPG) in Atlantic Canada. Since graduating from Saint Mary's University with a Diploma in Engineering Anthony then completed his Bachelor of Science in Engineering at the University of Prince Edward Island School of Sustainable Design in 'Design Engineering'. Anthony has worked as a HDPE fusion technician, prior to beginning his Bachelors program and since this beginning his Technical Sales role with EPG.

Some of Anthony's awards and accomplishments are:

- ISOCS/IEEE International Symposium on Olfaction and Electronic Nose
- Canadian Society of Bioengineering Undergraduate project of the year
- HDPE Fusion Technician Certified (ASTM F2620-12)

AKVA group North America

AKVA group is a global technology and service partner that deliver technology and services that helps solve biological challenges within the aquaculture industry. Good operational performance and fish welfare ensures sustainability and profitability for the customer. This is the premise for everything that is delivered, from single components to services and complete installations. In-depth aquaculture knowledge, extensive experience and a high capacity for innovation characterizes and enables the delivery of the best solutions for both land based and cage based fish farming.

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Keith Richford

Keith Richford is the Commercial and Operations Manager at AKVA Group North America with over 30 years experience in aquaculture and feed systems.



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Independent Reviewer

Jamie Norris

Jamie Norris holds the position of Senior Construction Coordinator with Aker Solutions Canada. He is a Senior Mechanical Technologist with 15 years' experience in marine construction and project management. His familiarity with Norwegian and Canadian standards has afforded him a unique skillset. Mr. Norris has specialized in the oil and gas industry including major construction projects, offshore shutdown, hook-up, major modifications and off station projects. Chiefly, his specialty has surrounded piping including HDPE, fiberglass, carbon and steel with extensive emphasis on testing and hook-up work scope. Recently, Mr. Norris served as the Lead for major fabrication scopes of work for the Hebron GBS project before taking on the role of Offshore Hook-Up Lead for Hebron.

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Marine Communications Traffic Service

Grieg NL provides supporting documentation as needed and various other sources used as noted throughout the document.

Appendix II
Norwegian Standard NS 9415

Marine fish farms

Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation

Flytende oppdrettsanlegg

Krav til lokalitetsundersøkelse, risikoanalyse, utforming, dimensjonering,
utførelse, montering og drift

This is a translation of NS 9415:2009. All reasonable measures have been taken to ensure the accuracy of this translation, but no responsibility can be accepted for any error, omission or inaccuracy.

The English translation was published in April 2010.

This translation has not been adopted as Norwegian Standard.

Marine fish farms – Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation

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Foreword

NS 9415:2009 was adopted in November 2009.

NS 9415:2009 replaces NS 9415:2003.

This standard is produced and revised by *SN/K 156, Standardiseringskomiteen for rømmingssikre oppdrettsanlegg / SN/K 509 Slutføring av arbeidet med pr NS 9415*, with participation by:

- the Fisheries and Environmental authorities;
- research and development institutions;
- consultancy companies;
- fish farmers and
- suppliers of equipment.

The development is based on reports and studies from the above-mentioned interested parties, as well as experiences in the industry. The Secretariat function for the work has been performed by Standards Norway, and has been partly financed by the Ministry of Fisheries and Coastal Affairs. The revision has been based on the experiences which have been obtained from the 1st Edition of the Standard, as well as a separate research project.

It is assumed that users utilise the whole of the Standard and not just individual chapters of it. Chapters 1 – 7 specify requirements regarding marine fish farms and general requirements regarding its main components, while Chapters 8 – 11 specify requirements for each individual main component.

1 Scope

The purpose of the Standard is to reduce the risk of escape as a result of technical failure and wrong use of marine fish farms. The Standard sets requirements regarding design of marine fish farms and how it shall be documented, including calculation and planning rules. The Standard gives parameters which shall be used to indicate the condition of the site.

Requirements regarding design include requirements for all main components of marine fish farms, such as net pens, floating collars and rafts as well as requirements for functionality of the marine fish farm as a whole, including any extra equipment. A description is given of how marine fish farms shall be placed based on the site conditions at the given site. The Standard also sets requirements as to how marine fish farms shall be operated in order to be acceptably escape-proof.

Technical requirements or operational tasks which are not relevant to escape of farmed fish are not included in this Standard. The Standard does not completely cover all the circumstances which can be relevant for escape. However, it is assumed that such elements are included in the risk analyses, even though they are not explicitly mentioned in this Standard.

2 Normative references

The following referred documents are necessary for the application of this document. For dated references only the edition mentioned applies. For undated references the last edition of the referred document (including corrigendum) applies.

NS 416-1	Operators for welding of polyethylene (PE) and polypropylen (PP) pipes and fittings - Part 1: Certification
NS 416-2:2008	Operators for welding of polyethylene (PE) and polypropylene (PP) for pipes and fittings - Part 2: Training schedule
NS 470	Welded steel structures - Rules for design and fabrication
NS-EN 1990	Eurocode - Basis of structural design
NS-EN 1991-1-4	Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
NS-EN 1992-1-1	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
NS-EN 1993-1-1	Design of steel structures - Part 1-1: General rules and rules for buildings
NS-EN 1999-1-1	Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules
NS 5814	Requirements for risk assessment
NS 6082	Marine industry - Deck and bulkhead pieces of pipe with threads for plastic pipes
NS 9425-1	Oceanography – Part 1: Current measurements at fixed points
NS 9425-2	Oceanography - Part 2: Current measurement using ADCP
NS-EN 287-1	Qualification test of welders - Fusion welding - Part 1: Steels
NS-EN ISO 15607	Specification and qualification of welding procedures for metallic materials - General rules (ISO 15607:2003)
NS-EN 473	Non-destructive testing - Qualification and certification of NDT personnel - General principles
NS-EN 1677-1	Components for slings - Safety - Part 1: Forged steel components, Grade 8
NS-EN 1677-2	Components for slings - Safety - Part 2: Forged steel lifting hooks with latch, Grade 8
NS-EN 1677-3	Components for slings - Safety - Part 3: Forged steel self-locking hooks - Grade 8
NS-EN 1677-4	Components for slings - Safety - Part 4: Links, Grade 8
NS-EN 10204	Metallic products - Types of inspection documents

NS-EN 12201-2	Plastics piping systems for water supply - Polyethylene (PE) - Part 2: Pipes
NS-EN 13173	Cathodic protection for steel offshore floating structures
NS-EN 13889	Forged steel shackles for general lifting purposes - Dee shackles and bow shackles - Grade 6 – Safety
NS-EN 14687	Mixed polyolefin fibre ropes
NS-EN ISO 1107	Fishing nets - Netting - Basic terms and definitions (ISO 1107:2003)
NS-EN ISO 1140	Fibre ropes - Polyamide - 3-, 4- and 8-strand ropes (ISO 1140:2004)
NS-EN ISO 1141	Fibre ropes - Polyester - 3-, 4- and 8-strand ropes (ISO 1141:2004)
NS-EN ISO 1346	Fibre ropes - Polypropylene split film, monofilament and multifilament (PP2) and polypropylene high tenacity multifilament (PP3) - 3-, 4- and 8-strand ropes (ISO 1346:2004)
NS-EN ISO 1805	Fishing nets - Determination of breaking force and knot breaking force of netting yarns (ISO 1805:2006)
NS-EN ISO 1806	Fishing nets - Determination of mesh breaking force of netting (ISO 1806:2002)
NS-EN ISO 2307	Fibre ropes - Determination of certain physical and mechanical properties (ISO 2307:2005)
NS-EN ISO 9606-2	Qualification test of welders - Fusion welding - Part 2: Aluminium and aluminium alloys (ISO 9606-2:2004)
NS-EN ISO 12944-2	Paints and varnishes - Corrosion of steel structures by protective paint systems - Part 2: Classification of environments (ISO 12944-2:1998)
NS-EN ISO 12944-3	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 3: Design considerations (ISO 12944-3:1998)
NS-EN ISO 14731	Welding coordination - Tasks and responsibilities (ISO 14731:2006)
NS-EN ISO 15609-1	Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1:2004)
NS-EN ISO 15614-1	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)
NS-EN ISO 15614-2	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 2: Arc welding of aluminium and its alloys (ISO 15614-2:2005)
ISO 1704	Ships and marine technology - Stud-link anchor chains

3 Definitions

The following definitions apply in this Standard in addition to those that appear in NS-EN ISO 1107:

3.1

analysis

calculation of load effects on a construction
[NS 3472]

3.2

seizing

class of knots

3.3

ultimate limit state

limit state connected to fracture or other similar forms of constructional failure

NOTE The ultimate limit state is usually equivalent to the maximum load-carrying capacity of a construction or a part of a construction.

3.4

user handbook

a document that describes the correct identification of parts, transport, storage, handling, assembly, interface, operation of and limitations regarding main components of a fish farm

3.5

serviceability limit states

limit state for when a construction or a construction part no longer meets designated requirements for normal use

3.6

bottom rope

horizontal rope between the side and bottom in a net pen

3.7

wave height

vertical distance between a wave crest and the previous wave trough

3.8

wave length

horizontal distance between a wave crest and the previous wave crest

3.9

wave period

the time a wave takes to move one wave length, defined between two zero lines of mean water level

NOTE The wave period is equivalent to the time between two consecutive wave crests passing through a fixed point.

3.10

wave direction

the direction the waves come from

EXAMPLE Waves with a direction of 270° come from the west.

3.11**buoy body**

part of a buoy having the function of keeping floating elements in place in the buoy

3.12**dartdrop-testing**

determination of the impact resistance of a material by a specified body falling towards the material at a specified force per area unit under specified conditions whereafter the effects are assessed

3.13**diffraction and refraction analysis**

calculation of wave height and period based on how local topographical conditions cause reflections, deflections and slowing down of ocean swells

3.14**design working life****lifetime**

the expected time period a construction or part of it, with an intended purpose and with expected maintenance, shall be able to be used without extensive repairs being necessary

3.15**design load**

load which shall be used in examination of a construction in the limit state indicated
[NS 3472]

3.16**design load effects**

load effects calculated on the basis of design loads
[NS 3472]

3.17**dimensioning**

determination of dimensions or establishment that the dimensions are sufficient to satisfy the requirements of the limit states
[NS 3472]

EXAMPLE An example of dimensions is stretching in a certain direction for a component. Length, breadth, thickness, height, depth, diameter or stretching along a certain line such as circumference.

3.18**documented competence**

written evidence that practical and theoretical skills are satisfied in relation to the requirements in an existing curriculum or training plan

3.19**operation**

fish farming at a site, including all operations which are performed at the site while fish farming is in progress, and which are relevant to escape

3.20**dynamic analysis**

analysis where a calculation is done of loads from wind, current and waves as well as acceleration as a result of wave movements in addition to mass, damping and rigidity of the construction

NOTE Load/response analysis where mass, damping and rigidity of the construction are included.

3.21

dynamic magnification factor

factor which indicates the relationship between response when mass, damping and rigidity are taken into consideration, and response when only the rigidity of the construction is taken into consideration

3.22

dead fish collector

dead fish scoop

tool for removal of dead fish from the net pen

3.23

depth of net pen

vertical distance from the waterline to the deepest point in the net pen in stretched condition

3.24

extra equipment

technical equipment, fixed or movable, which is used to perform certain operations at a fish farm

3.25

empirical design

design that has been based on experience with previously developed equipment

NOTE Empirical design only builds on strict engineering methods to a small degree.

3.26

re-examination

re-examination of documentation, planning, design and assembly of a marine fish farm with its main components and any extra equipment at the site

3.27

inspection

examination

systematic inspection/examination, usually visual, to see that the equipment satisfies the requirements that are set

3.28

stitching

seam for connection of rope and net

3.29

stitching rope

rope which is a part of the construction of the net pen, and which is stitched to the net pen

3.30

filament

fibre or strands which are used as a main component in net twine or rope

3.31

flexible installation

marine fish farm where the floating collar is primarily made of polymers, first and foremost plastic

NOTE There can also be marine fish farms where rubber is used as the most important material.

3.32**floating collar**

frame which provides buoyancy and attachment for one or more net pens

NOTE A floating collar is a complete unit consisting of a buoyancy pipe, clamps and the necessary extra equipment.

3.33**marine fish farms****total installation**

floating or submersible floating fish farm composed of main components, where live fish are fed, treated or stored

3.34**raft****barge**

floating work station having a gross weight of over 50 tonnes, detached or integrated, with technical equipment for performing certain functions connected to fish farming

NOTE Such functions can be storage, feeding, electricity supply, crewing and monitoring of the site

3.35**transfer**

moving of equipment internally on the site or between sites

3.36**mooring**

system of lines and bottom attachments for keeping the floating collar in the desired position

3.37**mooring line**

part of the mooring and includes frame stretch and crowfoot as well as a line to the bottom attachment

3.38**fully developed sea state**

sea state with a wave height which does not increase even though the wind continues at the same strength

3.39**operability inspection**

inspection which is undertaken at given intervals to discover any weaknesses connected to the equipment's operability or stability, particularly with regard to wear

NOTE Intervall for funksjonsettersyn kan for eksempel være månedlig. Interval for operability inspections can be monthly, for example.

3.40**walkway**

device where operations personnel can move on foot

3.41**global analysis**

determination, in a construction, of a consistent set of either internal forces or stresses which are in equilibrium with a determined set of effects on the construction, and which depend on geometrical characteristics, the construction's characteristics and the characteristics of the materials

[NS 3490]

3.42

chafing

weakening of strength of equipment as a result of cut or friction

3.43

limit state

condition defining the limit for when a construction no longer meets the dimensioning criteria

3.44

GZ curve

curve which describes a floater's or raft's stability in relation to the heeling angle

3.45

ocean swell

heavy sea

breakers

waves that are generated over and which penetrate from open sea

3.46

jump catch net

part of the net pen placed between the top rope and main rope

3.47

main component

one of four components which a marine fish farm consists of, namely net pen, floating collar, raft and mooring

3.48

main rope

horizontal rope placed under the top rope, where the net pen is attached to the floating collar

3.49

instruction

detailed description of how an operation shall be performed

NOTE An instruction cannot be derogated from

3.50

irregular sea

sea state where the waves have heterogeneous wave characteristics

3.51

JONSWAP wave spectrum

theoretical distribution of the energy in waves based on measurements taken in shallow areas in the North Sea, near land

NOTE The spectrum is based on significant wave height, peak period and the peak parameter

3.52

capacity

mechanical characteristic of a part, a transverse section or a construction part connected to the ultimate limit state

[NS 3472]

3.53**characteristic load**

load with a fixed probability, based on years' extremes, so that it shall not exceed one single year. For loads which are specified with maximum values which are not allowed exceeded, the maximum value is used as the characteristic load

[NS 3472]

3.54**characteristic capacity**

value for a construction's resistance or strength based on a fixed probability so that the mentioned value is not reached during the dimensioned useful life of the construction

3.55**eyelet**

device to protect a rope bow

3.56**impact**

possible result of a undesirable event. Impacts can be expressed with words or as a numerical value for the scope of damage/injury to people, environment or material values

[NS 5814]

3.57**impact-reducing measures**

measures aimed at reducing impacts of an undesirable event

[NS 5814]

3.58**construction calculation**

calculation showing that the requirements regarding the limit states are met

[NS 3472]

3.59**cross rope**

continuation of a vertical rope, which on its own or together with others crosses the bottom of the opposite vertical rope

NOTE Any other ropes which are to be installed on the bottom are not regarded as cross ropes in this Standard.

3.60**quasi-static analysis**

analysis where calculation is made of loads from wind, current and waves, whilst accelerations on the construction as a result of waves and current are neglected

NOTE Load/response analysis where rigidity of the construction is included together with a dynamic magnification of load.

3.61**storage**

storage of the whole or parts of a main component which is not in use

3.62

load

applied concentrated and distributed forces which act upon the construction and applied displacement or strains in the construction

NOTE The term "load" is used mainly in the same meaning as the form "effect". "Load" is often used to describe only the effects of force, but in this Standard also includes the effects of applied displacements and strains.

[NS 3472].

3.63

load factor

load coefficient

partial factor for load, which expresses possible deviation for the loads in relation to the characteristic capacities, reduced probability for different loads to act at the same time with their characteristic capacities, and uncertainties in modeling and analysis in the determination of load effects

3.64

load effect

the results of effects on the construction, such as action-effect, moment, stress, strain or displacement
[NS 3472]

3.65

plumb

weight or other device fixed directly or indirectly to a net pen in order to stretch it

3.66

log

written documentation that records actions taken, as well as the time, and the persons performing them

3.67

local analysis

determination in a construction detail of a consistent set of either internal forces and moments or stresses which are in equilibrium with a certain set of effects on the construction, and which depend on geometrical characteristics, the characteristics of the construction and the characteristics of the materials

3.68

lifting rope

vertical rope which continues as cross rope at the bottom of the net pen

3.69

maximum wave height

highest wave registered within a period of three hours

3.70

mesh

opening in the fishing net, including the twine that form the limits of the opening

NOTE In net pen there are two mesh types which are used, determined by the geometry of the mesh, namely, square mesh and hexagonal mesh.

3.71

size of mesh [NS-EN ISO 1107]

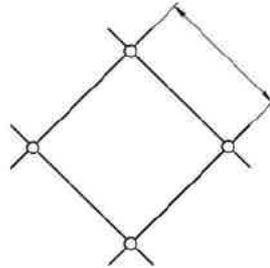
NOTE In NS-EN ISO 1107 the mesh size is only defined by sub-terms (see 3.69.1, 3.69.2 and 3.69.3).

3.71.1

length of the mesh side

half-mesh

Length of the mesh side measured from centre to centre of two consecutive joins
[NS-EN ISO 1107]



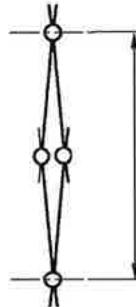
3.71.2

mesh length

whole mesh

distance between the centre of two opposing knots/joins in the same mesh when the mesh is fully stretched

[NS-EN ISO 1107]

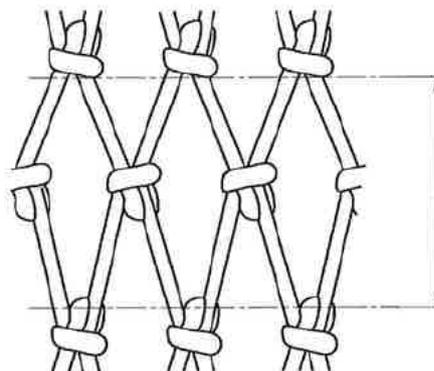


3.71.3

mesh opening

distance between two opposing knots/joins in the same mesh when the mesh is fully stretched

[NS-EN ISO 1107]



3.72

material factor

material coefficient

factor expressing possible deviation in strength of materials in relation to characteristic values, possible strength reduction of materials in the construction as a whole in relation to characteristic values derived from tests and uncertainties with modelling and the determination of the construction's capacity, including specified tolerances

3.73

cage

floating collar with fixed net pen

3.74

marking

unambiguous identifier on a main component or parts of it, in order to simplify retrieval and traceability

3.75

environmental load

load on a marine fish farm from wind, current, waves, ocean swell, tide and ice

3.76

assembly

installation

composition of a main component or parts of it or composition of main components and/or extra equipment of a marine fish farm at a site

3.77

net buoyancy

total buoyancy with a deduction of the weight of all parts of the system

3.78

net

fishing net used in a net pen

3.79

net pen

net

fish farming net

completely assembled bag of net to keep farmed fish in place

3.80

partial coefficient

load factor or material factor

3.81

partial coefficient method

dimensioning method which leads to the desired safety level by application of partial coefficients together with characteristic values for loads and the construction's resistance

3.82

permeability

measure for water penetration

3.83**peak period**

wave period where the energy in the wave spectrum is greatest

NOTE This period is equivalent to the period for the highest waves.

3.84**production documentation**

work descriptions and drawings that personnel shall have in order to be able to perform the work in relation to planning assumptions

[NS 3472]

3.85**produktspesifikasjon**

technical documentation of equipment

3.86**procedure**

description of how an operation is normally performed

NOTE A procedure can be derogated from if certain conditions indicate it.

3.87**planning**

design, dimensioning and planning of performance

3.88**reliability**

the capability of the construction or part of the construction to meet the designated requirements they are dimensioned for, including design working life. Reliability is usually expressed by the use of terms for probability

[NS 3490]

NOTE Reliability includes the safety, use characteristics and durability of the construction.

3.89**reliability factor**

factor used to grade the requirements regarding equipment based on expected impacts in the event of failure or destruction

3.90**redundance**

further capacity in addition to the safety factors operated with

NOTE This can be formed by the difference between yield stress and breaking stress, plastic utilisation of cross section, or transfer of storage of forces due to constructive design. Regardless of redundance the capacity is exceeded when breaking stress is exceeded.

3.91**regular sea**

sea state where the waves have uniform wave characteristics

3.92**railing**

device to prevent personnel from falling into the sea, and for attaching jump catch nets and bird nets

3.93

repair

operation to restore the function, capacity and strength of equipment

3.94

risk

danger that undesirable events represent for humans, environment and material values. The risk is expressed by the probability for, and impact of, undesirable events

[NS 5814]

3.95

risk analysis

systematic procedure to describe and/or calculate risk. The risk analysis is performed by mapping undesirable events and the causes and impact of them

[NS 5814]

3.96

risk-reducing measures

measures with the aim of reducing the probability for and/or impacts of undesirable events

[NS 5814]

3.97

risk evaluation

comparison of results of the risk analysis with acceptance criteria for risk and other decision criteria

[NS 5814]

3.98

routine inspections

inspections that are made frequently, such as at given intervals or after special events, in order to discover any faults or defects which can be attributed to use, weather conditions, vandalism etc.

NOTE Intervals for routine inspection can be weekly.

3.99

probability

measurement for how often an event is expected to take place per unit of time

3.100

probability for exceeding

measurement for how often a given threshold is exceeded on average during a given time period

NOTE When a significant wave height is said to have an annual probability for exceeding of 0.02 (1/50), it means that this wave height on average is exceeded once every 50 years. This wave has a return period of 50 years. The wave is referred to as the 50-year wave.

3.101

probability-reducing measures

measures for reducing the frequency of an undesirable event

3.102

sequential main inspection

inspection which is undertaken at fixed intervals in order to determine the equipment's level in relation to loads, function, stability, capacity and strength

NOTE Interval for sequential main inspections can be semi-annual.

3.103**vertical rope**

vertical rope in the net pen

3.104**significant wave height**

average wave height for the highest third of the waves in one registration

3.105**significant wave period**

average wave period for the highest third of the waves in one registration

3.106**safe knot**

knot that does not loosen or cause the rope to be broken because of function or imposed loads in mooring or net pen

NOTE A knot that reduces the strength of the rope as little as possible shall be sought used.

3.107**solidity**

the relationship between the planned net area and total area on a net panel

3.108**peak parameter**

indicates the width of the JONSWAP spectrum around the peak period

3.109**fetch**

distance from the site to closest land, calculated in the wind direction

3.110**velocity of current**

vectorial average of velocity of current over a ten-minute measurement period

3.111**direction of current**

direction in which the current is flowing

NOTE Current with 90° flows towards east. Current is stated in the opposition direction in which waves and wind move, because of the different oceanographic conventions.

3.112**additional information****disseminated information**

extra information which describes a measurement

NOTE This can be time, position, measuring depth, calibration data, type of instrument, institution and operator for a current measurement series.

3.113**top rope**

uppermost horizontal rope on a net pen

3.114

transport

moving of equipment from producer/supplier to fish farmer

3.115

twine

spun filament

3.116

accident limit state

limit state resulting when a construction is put under an accidental load

NOTE Accidental load can be caused by collision or a break in moorings

3.117

accidental load

load, usually short-term, but of a considerable size, which a given construction with little probability will be exposed to during the design working life

NOTE An accidental load can in many cases be expected to lead to serious impact unless suitable measures are taken.

3.118

design

determination of the structure of main components

3.119

production

production of components at a workshop and factory as well as installation of them or parts of them at the site

NOTE Components here can mean main components or parts of them.

3.120

fatigue limit state

limit state quantifying the danger of fracture during the useful life of the marine fish farm because of repeated loads

3.121

replacement

replacement of a main component or parts of it by removing it and replacing it with another

3.122

stretching system

extra equipment which shall contribute to keeping the net pen in the desired three-dimensional form

NOTE This can be weights, bottom ring, etc.

3.123

undesirable event

an event or condition which can entail injury to humans, or damage to the environment or material values [NS 5814]

3.124

maintenance

operation which shall prevent that equipment is weakened in relation to the intended function, capacity, and strength

3.125**wind velocity**

average wind velocity in a defined direction over a ten-minute interval, measured at ten metres above ground level

3.126**wind direction**

direction from which the wind is coming

NOTE A wind with the direction of 180° comes from the south.

3.127**wind sea**

waves which are generated by wind locally in relation to the site

4 Symbols

a	Number of cycles in a cyclic course
B	Width
D	Depth
D	Diameter of a pipe
DAF	Dynamic amplification factor
DH	Artificial shear deformation
DH_{char}	Characteristic shear deformation
$DH_{char,n \text{ cages}}$	Characteristic shear deformation in a double line of net pens with n cages in line
E	Elasticity module
E_{sig}, E_{rel}	Viscous elasticity factors
EPS	Expanded polystyrene
F	Occurring load on cages in newton
F_b	Load due to fouling on the net pen
F_e	Effective fetch length in metres, corrected distance from the site to the nearest land calculated in the direction of the wind
F_e	Cracking stress
F_e	Self- load of net pen
F_h	Load on net pen upon handling
F_s	Maximum load from current on the net pen
F_w	Load from waves on the net pen
FEM	Finite Element Methods
GZ	Curve for stability in relation to heeling angle
H	Ocean swell
H	Regular wave height in metres (ocean generated)
H_{maks}	Maximum wave height in metres in a measurement of three hours duration and a return period of 50 years
H_s	Dimensjoning, significant wave height in a measurement of three hours duration and a return period of 50 years
I	Ice formation in kg/m^2 during a 48-hour period
ID	Identification

IMO	International Maritime Organization
JONSWAP	Joint North Sea Wave Project
k_1, k_2	Freeboard requirement
K2	Specified chain quality in relation to the stress level
L	Length
L	Design working life in number of years
L	Load on the net pen
L_p	Characteristic peak length
LOA	Largest length of a raft, given in metres
MBL	Minimum breaking load
n, N	Number of cycles to fracture
N_i	Number of cycles to fracture
NDT	Non-destructive testing
P	Return period
PA	Nylon
PE	Polyethylene (polythene)
PM	Pierson Moskowitz spectrum
PP	Polypropylene
PU	Hardened polyurethane foam
PVC	Hardened polyvinylchloride foam
Q	Pump capacity
R	Strength of a (main) component
S_r	Design load effect
SCF	Stress concentration factor
SN	Curve indicating stress in relation to the number of cycles
T	Regular wave height
T_p	Peak period in the wave spectrum for a measurement period of three hours duration
T_{p2}	Defined peak period in the spectrum
T	Thickness of pipe wall
U	Wind velocity
U_{10}	Wind velocity measured 10 metres above water surface, averaged over a ten-minute period
UV	Ultraviolet radiation
U_A	Adjusted wind velocity
V	Wind sea
V	Average wind velocity for a ten-minute interval measured 10 metres above ground level
V_c	Current velocity averaged over a ten minutes measurement period and a return period of 10 years
V_s	Current velocity
WPS	Approved welding procedure
XC3	Defined exposure class
\varnothing	Diameter of waste pipe
ψ	Reduction factor

$\Delta\sigma$	Difference between the highest and lowest stress level in a cyclical course
γ	Peak parameter
γ_f	Load factor
γ_m	Material factor
σ_{flyt}	Yield stress of the material
σ_s	Nominal stress range of the material
σ_{maks}	Maximum stress level of the chain in a cycle
σ_{min}	Minimum stress level of the chain in a cycle

5 Site surveys

5.1 General

The site shall be surveyed and described based on topography and degree of exposure in the form of parameters that shall form the basis for calculation of environmental loads on an installation. Measurements shall be performed on empty sites, i.e. a site without an installation, if possible. When measurements are taken with an installation in place at the site, they shall be taken into consideration in the determination of the environmental parameters.

See otherwise information Annex A for more background information concerning site surveys.

All assessments which are made during the site survey shall be documented.

5.2 Determination of velocity of current

5.2.1 General

Either para. 5.2.2, 5.2.3. or 5.2.4. shall be used in determining current velocities.

Measurements shall be done at a minimum of two levels, 5 m and 15 m respectively below sea level, where topography allows.

Measurements shall be undertaken at a place at the site which is expected to have the highest current velocities and shall be representative of the areas where the fish farm is to be located. The measurement site shall be indicated and justified. Logging of current shall take place at least every 10 minutes and form the basis for the dimensioning current velocity at the site. Previous measurements which are logged every 30 minutes can be used when current data is to be collated for a complete year.

Measurement of current velocity entails registration of both time, velocity and direction during the whole of the measurement period. Current measurements shall take place in accordance with NS 9425-1 and/or NS 9425-2, dependent on the bottom depth of the site and exposure.

Which critical current components contribute to the total current overview shall be assessed and documented:

- tidewater current;
- wind-induced surface current;
- outbreak from the coastal current;
- spring flood because of snow and ice melting.

Quality assessment of measurement data of current measurements shall be performed, and include:

- credibility;
- factors during the measurement period that can have affected the measurements.

5.2.2 Measurements of current for one year and use of long-term statistics

Data for current velocity shall be obtained by measurements of at least 12 months' duration at the site. The data shall be processed by using harmonic analysis with subsequent harmonisation of long-term

statistics. It is possible to assemble several partial measurements of at least 4 weeks' consecutive duration which together cover one calendar year.

5.2.3 Measurement of current for one month

In order to determine dimensioning current velocity with a specified return period, the multiplication factors in Table 2 shall be used.

Table 2 – Multiplication factor as a result of return period, used with one month's current measurement

Return period years	Multiplication factor
10	1,65
50	1,85

If the highest dimensioning current velocity with a return period of 50 years, based on a measurement over one month is lower than 50 cm/s, the dimensioning current velocity (50 years' return period) at the site shall regardless be set at 50 cm/s. The other values in the current rose shall be increased equivalently percentage-wise. If it can be substantiated that the current measurement over one month has captured maximum current for twelve months, the requirement for setting the dimensioning current at 50 cm/s can be waived. A further description of the various current components (see 5.2.1) shall be included in the assessment. The assessments shall be documented.

5.2.4 Use of previous current measurements

Existing current measurements can be used if they meet the requirements stated in para. 5.2.2 or 5.2.3. Measurements at other depths than those specified in para. 5.2.1 may be used, provided that it is possible to use them to estimate the current velocity at the stated depths by interpolation.

NOTE By using measurements undertaken at depths other than 5 m and 15 m respectively, extrapolation cannot be used to estimate the current velocity at the mentioned depths.

5.3 Determination of waves

5.3.1 Determination of wind-induced waves

5.3.1.1 General

The method for determination of waves shall be documented. Wind-induced waves shall either be determined by wave measurements or by calculation in accordance with para. 5.3.1.4. Wave measurements shall be further processed in accordance with para. 5.3.1.2 or 5.3.1.3.

NOTE 10-years' wind and 50-years' wind for determination of waves can be decided in accordance with NS-EN 1991-1-4.

In addition to the methods described below, a wave chart can be based on long-term wave measurements if they cover the relevant site.

Re-examination of the measurement data of wave measurements shall be performed, and shall include:

- credibility;
- factors during the measurement period that can have affected the measurements.

5.3.1.2 Irregular sea

In the event of irregular sea, the JONSWAP spectrum shall be used with $\gamma = 2.5$ for wind sea and $\gamma = 6.0$ for swells. Alternatively, in fjords or in other partly sheltered sites, a 2-parameter PM spectrum (Pierson Moskowitz spectrum) can be used. A fully developed sea state shall be assumed.

5.3.1.3 Regular sea

With the use of regular sea, regular wave height shall be assumed, equal to:

$$H = H_{\max} = 1,9 \cdot H_s$$

Regular wave period shall be set at the peak period T_p

5.3.1.4 Calculation of waves based on effective fetch length

Wind-induced waves shall be calculated based on wind data from para. 5.4.2 and fetch length measured on a sea chart. Dimensioning, significant wave height shall be determined based on effective fetch length and 10-minute average wind at 10 m height, and such that the wave height increases (approximately) proportionally with the wind velocity and proportionally with the square root of effective fetch length. The 50-year wave shall be determined based on the site's 50-year wind. The 10-year wave shall be determined based on the site's 10 year wind.

Calculate the adjusted wind velocity U_A by using the wind velocity U_{10} (m/s):

$$U_A = 0,71 U_{10}^{1,23}$$

Significant wave height H_s and equivalent peak period in the wave spectrum T_p as well as effective fetch length F_e is given by:

$$H_s = 5,112 \cdot 10^{-4} U_A F_e^{1/2}$$

$$T_p = 6,238 \cdot 10^{-2} (U_A F_e)^{1/3}$$

Effective fetch length shall be found by the use of a recognized method, and used together with an angle opening of maximum $\pm 12^\circ$. Peak period and dimensioning, significant wave height are found by using Annex C or the formulas stated above.

5.3.1 Determination of ocean swells

An assessment shall be made and documented of whether ocean swells occur at the site. If ocean swells occur at the site, the wave height and period are calculated by using one of the following:

- diffraction and refraction analysis;
- measurements for determining swells with a return period of 10 years and 50 years;
- other recognised methods which can document safety, validity and accuracy.

In the case of ocean swells at the site, the combined sea state shall also be determined by combining calculated ocean swells with calculated, wind-induced waves.

5.3.2 Other wave conditions at the site

If para. 5.3.1.4 *Calculation of waves based on effective fetch length* is used to determine the waves, the following effects shall be assessed and documented to see how far they can affect the wave spectrum:

- ship-generated waves
- wave reflection (such as if the site is located near a steep mountainside or similar);
- effect of several wave trains (such as if two fjord systems meet or by combination of wind-induced sea and ocean swell);
- wave / current interaction (changes of wave spectrum at the site with a lot of current).

These conditions can contribute to changing the wave spectrum in the form of an increased significant wave height or changed peak period. The result of the analyses can lead to providing several wave spectra for the site.

5.4 Determination of wind velocity

5.4.1 General

NS-EN 1991-1-4 shall be used in order to determine the wind velocity for calculation of wind-induced waves.

To find the wind conditions for calculation of the wind load on rafts, extra equipment or ice-covered marine fish farms, either NS-EN 1991-1-4 or 5.4.2 shall be used, with a 50-year return period.

5.4.2 Use of wind data from meteorological stations

Measurements from the nearest or the nearest two weather stations³⁾ shall be used. Long-term statistics shall be prepared if they are not available from the weather station's data. Long-term statistical mean wind velocity shall be determined with a return period of 10 years and 50 years respectively.

Use of wind data from weather stations shall always be accompanied by a documented assessment of the site in question in relation to the weather stations. Elements which shall be taken into consideration are the distance between weather stations and the site, degree of sheltering of the site in relation to the weather stations and critical wind directions.

5.5 Determination of the effects of ice

5.5.1 Icing, particularly in combination with bad weather and reduced accessibility

Danger of icing on marine fish farms and appurtenant fixed equipment shall be documented. That shall be done on the basis of the following meteorological data for the site:

- air temperature;
- wind and exposure to wind;
- waves and exposure to waves;
- sea temperature.

If nothing else is documented 850 kg/m³ up to 10 m above sea level shall be used for mass density of ice.

In total, this will give an icing potential giving a dimensioning icing over a defined time interval. The period for continuous accumulation of ice shall be assessed based on the possibility of removal of ice and documented measures for icing prevention. If nothing else is documented, three 24-hour periods shall be used.

Determination of ice and icing potential shall be done based on recognised methods. Use of numerical methods shall be documented. Possible experiences regarding the site shall be collected for the assessment.

5.5.2 Drift ice

The danger of drift ice at the site shall be assessed and documented. Sources of drift ice can be fresh water reservoirs (lakes), rivers and river estuaries, river mouths and brackish water areas, sheltered fjords and sounds with sea ice. An indication shall also be given of which parts of the year drift ice can occur. The assessments shall be performed based on meteorological data and possible sources compared to any local knowledge.

5.5.3 Freezing over

The danger of the site freezing over shall be assessed and documented, with an indication of a possible time of year that this can occur. This shall be performed by assessing meteorological data compared to local knowledge of the site.

³⁾ The Norwegian Meteorological Institute has several weather stations that cover the whole country.

5.6 Description of water depth, bottom type and topography

Bottom topography and type at bottom attachments and along mooring lines shall be charted. Bottom depth in the relevant area for the marine fish farm, including mooring, shall be charted in a grid with the greatest distance of 10 m × 10 m between the registered points. Large irregularities, such as large stones, spines, fissures or larger object, shall be especially noted.

5.7 Direction of current, waves and wind

Values for current, waves and wind shall be indicated in at least 8 concurrent directions.

5.8 Documentation of site inspections and site reports

5.8.1 Documentation of measured parameters, calculations and conclusions

5.8.1.1 General

All information which characterises the site shall be presented so that the user can utilise them easily. All procedures shall be described or contain references to a separate description. The connection between processed data and supporting raw data and additional information shall appear. The documentation shall treat all the points below, where this is relevant. An inspection of the site shall be documented through a separate site reports.

5.8.1.2 Instruments

The following shall be included:

- instrument description for sensors, including producer, serial number and measurement principle in the form of reference to publication or short description;
- any modifications of the instruments;
- accuracy, resolution capability, and area of response for each sensor;
- calibration standard (such as procedures, quality and dates);
- conversion constants;
- any resolution in relevant dimensions;
- instrument log with relevant historical information.

5.8.1.3 Data collection and data processing

The following shall be included:

- type of measurement, including instantaneous value, average value and registration of disruption;
- measurement interval;
- duration of determination of each average period;
- number of raw data measurements for each presented data value;
- real measurement period for processed data;
- procedures for reduction of noise, filtering and data compression.

5.8.1.4 Data editing and quality control

The following shall be included:

- short description of procedures for data editing;
- short description of procedures for quality control;
- reference to type of quality control.

5.8.1.5 Data quality

The following shall be included:

- report on data quality and errors or uncertainties, such as fouling on instruments;
- report on correction of data, including treatment of errors and deviations.

5.8.2 Basis for charts

A detailed chart showing moorings lines and cages, with given scales, shall be made.

6 Load and load combinations

6.1 Dimensioning situations

A marine fish farm shall be dimensioned so that farming can be carried out without farmed fish escaping as a result of technical failure. The dimensioning situations shall be sufficient and at the same time be so varied that they include relevant circumstances which can occur during installation, operation, repair and maintenance of the marine fish farms.

The following sequences shall be included in a dimensioning analysis:

- determination of the loads;
- determination of effects of the loads;
- determination of resistance to the effects of loads;
- control in relation to defined limit states.

Sufficiently great probability shall be proved that the marine fish farm functions as it should in limit states.

6.2 Partial co-efficient method

Partial co-efficient method means defining limit states to which the marine fish farm can be exposed, based on load factor and material factor.

The load factor, γ_f , shall take the following into consideration:

- possible unfavourable deviation for the loads in relation to the equivalent characteristic values;
- reduced probability for different loads behaving at the same time with their characteristic values;
- uncertainties in modelling and analyses in the determination of load effects.

The material factor, γ_m , shall take the following into consideration:

- possible unfavourable deviation from the strength of the materials in relation to the equivalent characteristic values;
- possible reduced strength of materials in the marine fish farm as a whole in relation to characteristic values connected to individual parts;
- uncertainties in modelling and determination of strength of the marine fish farm, including specified tolerances.

NOTE Uncertainty in the yield strength values of the material can be an impact of erroneous production and damage and weakening which can occur during installation and use, including reduction of yield strength values as a result of temperature (variations), corrosion, ageing, photochemical oxidizing, UV rays etc.

The material factor shall also be based on the requirements described in para. 7.5.

Design load effect, S_f , is the load effect from characteristic loads multiplied by load factor γ_f .

Design load factor, S_f , shall fulfill the following expression for each (main) component:

$$S_f \leq \frac{R}{\gamma_m}$$

where

- S_f is the design load effect; average force, or stress
- R is the strength of a (main) component
- γ_m is the material factor

See also NS-EN 1990.

6.3 Characteristic values

Characteristic values shall be determined as loads which the marine fish farm with a defined probability will not exceed during its design working life.

Characteristic capacity for resistance shall be based on a defined probability that they will not be under-reached during the dimensioned useful life of the fish farm.

6.4 Limit states

Dimensioning shall be done in relation to two limit states:

- serviceability limit state;
- ultimate limit state.

Fatigue and accident situations shall be seen in regard to the ultimate limit state. The limit states shall be treated in accordance with NS-EN 1990.

6.5 Loads

6.5.1 General

During dimensioning, all load categories which can occur during the design working life of the marine fish farm, shall be assessed and documented, such as:

- permanent loads;
- variable function loads;
- deformation loads;
- environmental loads;
- accidental loads.

6.5.2 Permanent loads

The permanent loads represent loads which will not be removed during the design working life of the marine fish farm. These consist of:

- the weight of the marine fish farm in air, including permanent ballast;
- the weight of fixed equipment which cannot, or shall not, be removed;
- static buoyancy forces.

The permanent loads shall be determined based on accurate data regarding the density of the materials multiplied by the appurtenant volume and/or measured weight.

6.5.3 Variable function loads

Variable function loads are maximum loads which can be removed or relocated. They can be applied to the marine fish farm by:

- mechanical, movable equipment;
- personnel;
- stored goods, such as feed;
- variable ballast;
- mutual load between main components, such as floating collar and raft;
- normal boat impact, fendering and mooring of adjacent floating units;
- movable parts, as well as extra loads applied as a result of certain work operations.

6.5.4 Deformation loads

Deformation loads are loads which occur at forced deformation. This includes deformation which is due to the marine fish farm's function or circumstances in the surroundings, such as:

- pre-tensioning;
- mooring;
- temperature.

6.5.5 Environmental loads

Environmental loads are loads which are applied to the marine fish farm by environmental circumstances, such as:

- wind;
- waves;
- current;
- ice.

Unequally distributed ice shall be allowed for with the greatest ice load both on horizontal and vertical surfaces in accordance with para. 5.5.1 on the one side and no ice on the other side. In calculations, ice shall be treated as accidental load.

6.5.6 Accidental conditions / damage conditions

6.5.6.1 General

As a minimum accidental conditions / damage conditions shall be calculated, assessed and documented, and the impact of them shall be evaluated. This includes conditions such as:

- breaks in mooring lines;
- puncturing, disappearance or loss of floating parts.

Dead fish can also be regarded as accidental load. The calculations shall then be performed without combination with environmental loads.

6.5.6.2 Breaks in mooring lines

A marine fish farm shall be assessed for breaks in the mooring system. Progressive breaks shall be especially assessed. Breaks in each line shall be assessed. Breaks which weaken the stability of the mooring and functionality of the floating collar shall be assessed.

In particular, an assessment shall be made and documented, if necessary supported by calculations, of breaks in the following:

- breaks in lines carrying the largest load;
- breaks in lines which are critical for strength in the marine fish farm, especially the floating collar;
- breaks in the connecting points, such as coupling disc. Possible breaks in connecting points (including coupling discs) will vary based on the design of the connecting point. The break/tear form which gives the least capacity shall be regarded as broken. If the connecting point has probable break sections which entail that several mooring lines are out of function, this shall be regarded as accidental load;
- breaks in lines that are critical for positioning of single or groups of cages with common moorings, where relocation can lead to damage to adjacent cages.

6.5.6.3 Puncturing

The following situations shall be dimensioned for:

- water penetration in one floating element or between two bulkheads (when using hollow floating elements).
- loss of one floating element at a most critical place (when using floating elements filled with buoyancy materials).

6.6 Load factors

For different main components, the load factors in Tables 3, 4 and 5 shall be used.

Table 3 – Load factors for floating collars of steel and plastic in a serviceability limit state

Dimensioning situation	Permanent load	Variable functional load	Deformation load	Environmental load
Establishment of floating ability	1,0/0,9 ¹⁾	1,0	1,0	1,0 ²⁾
Establishment of capacity	1,0	1,0	1,0	1,3
Accident situation - Damaged condition ³⁾	1,0	1,0	1,0	1,0
¹⁾ Favourable load (buoyancy) and unfavourable load (weight) shall be regarded as separate loads. The favourable part has a load factor of 0.9, and the unfavourable part has a factor of 1.0. ²⁾ Applies to loads from ice and snow. ³⁾ Applies to breaks in mooring lines, puncturing and ice and snow				

Regarding serviceability limit states, all load factors are set at 1.0.

The values in Table 3 are used in dynamic analyses. In the event of quasi-static analysis, the stated load factors in Table 3 are multiplied by a dynamic amplification factor greater than or equal to 1.1. The basis for the factor shall be justified and documented. In order to establish the dynamic factors it is necessary to know the resonant frequencies of the construction and the load's variation in time and space. The analyses shall be performed in accordance with NS-EN 1990.

The load factors in Table 3 shall also be used for surfaces of steel and concrete respectively.

Table 4 – Load factors for mooring lines

Type of analysis	Load factor
Static analysis	1,6
Quasi-static analysis	1,15×DAF ¹⁾
Dynamic analysis	1,15
Accident limit (break in mooring line)	1,0
Spring flood	1,0
¹⁾ Here is used a factor of 1.15 multiplied by dynamic amplification factor (DAF). Dynamic amplification factor ≥ 1.1 . Choice of value of DAF shall be justified and documented.	

Table 5 – Load factor for rope in net pens, dimension Grade 0

Various components	Load factor
Net pen, dimension Grade 0	1,3
Net pen, dimension Grade 0, manual lifting equipment	1,5
Net pen, dimension Grade 0, mechanical lifting equipment	3,0

6.7 Load combinations

Table 6 indicates combinations of current, wind and waves for controls in ultimate limit states.

Table 6 – Combinations of environmental loads

Combinations	Return period, environmental load		
	year		
	Current	Wind	Wave
1	50	10	10
2	10	50	50

For controls in serviceability limit states a reduction factor, $\psi = 0.7$, is used for the loads in Table 6, see also NS-EN 1990.

Table 6 indicates combinations of current, wind and waves for control in ultimate limit states. In accident limit states the individual events shall be controlled under stress from the most unfavourable of the two environmental load combinations in Table 6. An assessment shall be made of which environmental load combination is the most unfavourable for each accidental event.

6.8 Calculation of the effects of load

Construction calculations shall be based on a suitable choice of stress-strain conditions for materials and connections. In general, it is assumed that the constructions will be linear elastic. Non-linear models can be used where indicated in the planning standards for the various materials.

If the dynamic loads can be regarded as quasi-static, the dynamic load variations can be taken into consideration, either directly in the static values or by multiplying the static loads by calculated dynamic factors.

7 General requirements regarding main components and marine fish farms

7.1 General

A marine fish farm shall have an appropriate technical design, and the fish farm shall be operated in an appropriate manner in order to avoid technical failure.

Planning of a marine fish farm shall be based on risk evaluation and ensure that it is adapted to the environmental conditions at the site. The requirements in this chapter regarding planning includes both the marine fish farm as a whole and its components.

7.2 Risk analysis

A risk evaluation shall be performed in connection with planning, production, delivery, installation and operation.

A risk analysis, broken down into probability and impact (degree of seriousness), shall be included.

The risk analysis shall be based on NS 5814 or equivalent. The various stages shall be documented so that they can be re-examined.

A risk evaluation shall be as complete as possible and also cover relevant conditions for escape which are not explicitly mentioned in this Standard.

NOTE An example of a partly performed risk analysis for operation is given in table form in Annex F.

7.3 Planning of main components and composition of marine fish farms

7.3.1 Reliability and control

NOTE Reliability class is used to determine requirements regarding control of planning and production in NS-EN 1990.

The reliability class for the main components and for the marine fish farm shall be determined by the number of fish that can escape in the event of failure or collapse. A main component can have a lower or higher reliability class than the rest of the marine fish farm, according to the impact of failure.

Marine fish farms in Reliability Class 2 normally require *normal inspections*, which entail an internal, systematic control by other personnel in the company than the/those person(s) who originally performed the work. Control of planning shall include random sample control of load effects and of the capacity of main elements.

Marine fish farms in Reliability Class 3 normally require *extended inspections* of planning and production. These shall be performed by another company than the one performing the work. Inspection of planning shall in that case include independent analyses and capacity controls. So that analyses and capacity controls performed by a certifying body shall be regarded as extended inspection, previous calculations must be available from the Supplier.

Reference is also made to NS-EN 1990 regarding what the inspections shall include.

NOTE Risk of escape varies according to which main component fails. Collapse of mooring could lead to all fish in the marine fish farm escaping, and collapse of the net pen to escape of the fish in the net pen.

Table 7 – Reliability factor for floating collar/net pen and mooring respectively in relation to the number of fish

Number of fish in the floating collar/net pen	Number of fish in common mooring	Reliability class
n < 500 000 individuals	n < 1 000 000 individuals	2
n ≥ 500 000 individuals	n ≥ 1 000 000 individuals	3

If one of the criteria for that is present, the reliability class is set at 3, if relevant.

If one of the criteria for that is present, the reliability class is set at 3, if relevant. For net pens, differentiation shall be made between the probability of failure in the form of small cracks and collapse in the form of breaks in the rope attached to the twine or progressive tears.

NOTE Reliability classes for other social constructions are given in NS-EN 1990. Here the fish farming installations are designated "fishing harbours" and placed in Reliability Class 2.

7.3.2 Planning of (the whole) marine fish farm

A marine fish farm shall be sufficiently reliable to prevent the impact of undesirable events. In order to achieve sufficient reliability, the marine fish farm shall be planned in accordance with the requirements set forth in NS-EN 1990 or equivalent.

In order to avoid potential damage, recorded during risk analyses, one shall seek to reduce the impact of an undesirable event and the probability for its occurrence. The following shall be done:

- avoid, eliminate, or reduce dangerous events to the marine fish farm installation;
- choose a load-bearing system which has a small risk of exposure to dangerous events;
- choose a load-bearing system which has little sensitivity to dangerous events;
- choose load-bearing systems which do not break down without warning;
- choose main components which are suitable for each other, which are well connected to each other, and which have defined interfaces where mutual effects between them are within defined limit values;
- choose suitable materials, perform professional design and detailing, choose skilled manufacturing and establish appropriate control procedures for planning, production and operation;
- provide sufficient information regarding expected use;
- store production documentation which unambiguously describes geometry, materials and other technical requirements;
- undertake new evaluations and describe requirements for changes if a marine fish farm is changed, the useful life changes in relation to design working life, or damage occurs, provided that this is significant to the escape risk.

7.3.3 Connecting points

A local analysis of critical connecting points shall be performed. Any testing shall be performed with the aid of applied loads, three-dimensional if necessary. The connecting points shall include, but not be limited to:

- coupling discs (between mooring lines and frames, etc.);
- attachment points (net pen and mooring to floating collar);
- attachment rings;
- knots;
- hinges;
- rock bolts.

A fatigue analysis shall be performed. An analysis regarding the ultimate limit state shall also be performed.

Coupling discs in moorings will experience forces from several directions. Analyses shall be performed which document the capacity in relation to this for all applicable loads to which such plates can be exposed. (See 11.3.3).

7.3.4 Planning and use of materials

Installations of steel shall be dimensioned in accordance with NS-EN 1993-1-1. Corrosion protection of steel installations shall be undertaken in accordance with NS-EN ISO 12944-2 and NS-EN ISO 12944-3. Any cathodic protection shall satisfy the requirements in NS-EN 13173.

Aluminium constructions shall be dimensioned in accordance with NS-EN 1999-1-1.

Concrete constructions shall be dimensioned in accordance with NS-EN 1992-1-1. Other materials shall be calculated and dimensioned in accordance with recognised standards.

7.4 Planning and production of main components

7.4.1 General

Planning and production shall be in accordance with NS-EN 1990.

The basis for the requirements regarding main components is that they shall be able to withstand the loads to which they will be exposed at a site.

The main components shall be dimensioned according to calculations regarding waves, wind and current in eight directions, as specified in para. 5.7. Deviations from the requirements for calculations in relation to the number of directions shall be justified based on a risk analysis, as described in para. 7.2. Single parts or main components or joining of single parts to the main components shall be dimensioned to tolerate the forces applied to them.

A main component shall be dimensioned in order to:

- function satisfactorily based on given assumptions, such as environmental forces;
- tolerate all assumed loads, including deformations, with satisfactory protection against breaking;
- show satisfactory protection against an undesirable event triggering a more significant event than the triggering event itself;
- show satisfactory resistance to mechanical, physical, chemical and biological effects, seen in relation to design working life.

Dimensioning shall take into consideration mutual influence between the main components, such as between the floating collar and net pen, floating collar and mooring, floating collar and raft, net pen and mooring, net pen and raft, mooring and raft, and between the main components and any extra equipment.

The main components shall be calculated in relation to probable configurations/connections with other main components. Documentation of possibilities and limitations in the use of equipment as a result of these calculations shall be available.

7.4.2 Design working life and durability

The design working life shall be determined for both the whole of the marine fish farm and its main components.

User handbooks for the main components shall contain information regarding design working life and associated requirements for condition control and maintenance procedures.

The planning objective shall be that fish farms remain suitable for use during the dimensioned useful life. In order to ensure sufficient durability, the following shall be taken into consideration:

- the use area is fish farming, without the escape of farmed fish;
- the functional requirements in this Standard;
- maximum environmental forces the marine fish farm withstands;
- the composition, characteristics and performance of the materials;
- choice of load-bearing system;
- the design of the parts and constructive detailing;
- requirements as regards skilled work, both during production and operation;
- scope of inspections;
- defined protection measures;
- condition control and maintenance during operation for the entire design working life.

Planning and mooring shall in addition take into consideration the seabed conditions, including depth, topography and seabed substrate, on the basis of the results of the site survey.

7.4.3 Criteria for determining when equipment does not have sufficient quality

The criteria for determining when main components/components do not keep sufficient quality shall appear in the documentation for the components.

7.5 Material characteristics

7.5.1 General

A characteristic capacity has a given probability for not being under-reached in an unlimited series of tests. It indicates a characteristic for a material, and is defined as the mean value for rigidity parameters and as the 5 % fractile of the statistical distribution of the material characteristic for rigidity parameters.

NOTE Material characteristics are usually provided by the material producer.

If a material characteristic is not provided, it shall be found by relevant, standardised tests under defined and relevant conditions, and a conversion factor shall be used if necessary so that the test results shall be representative of the material characteristics in the relevant construction.

The planning standards for the various materials shall be used to obtain values for material characteristics. For planning where steel is to be used, NS-EN 1993-1-1 shall be applied, for planning where concrete is to be used, NS-EN 1992-1-1 shall be applied. Correspondingly, other planning standards shall be used where they are to be found for other relevant materials. See also paras. 9.10 and 9.11 for steel and plastic installations respectively.

7.5.2 Galvanic conditions

Contact between metals/alloys of different qualities shall be avoided as much as possible. Where this nevertheless takes place, increased corrosion shall be evaluated and documented as a result of galvanic conditions, either through an after-inspection programme or by loss of strength calculations based on corrosion as a function of time. Corroded components shall be replaced in accordance with the requirements indicated by the evaluations.

7.5.3 Material parameters (rigidity, strength, corrosion, strain characteristics, density and design working life)

All material parameters shall be obtained from authoritative sources, such as supplier documentation connected to certified equipment or materials.

7.6 Extra equipment

7.6.1 Loads from extra equipment

In the planning phase of the floating collar, areas for extra equipment shall be defined, and this shall be taken into consideration in the planning analyses. These areas shall be indicated with the highest allowed total load, highest distributed load per m² and highest allowed concentrated load as well as the possibility for attachment. In the cases where no such areas are defined, or where extra equipment is planned installed outside the defined areas, documentation shall be provided that the marine fish farm tolerates the extra equipment which is to be installed. Extra equipment shall not lead to exceeding the marine fish farm's capacity, stability and strength. Separate evaluations shall be performed with appurtenant documentation for fixed and movable equipment respectively.

There shall be a user handbook and installation description for extra equipment which represents a danger of escape. See also Annex D. Extra equipment with self-buoyancy, which is moored as a part of or in connection with the installation, shall have documented buoyancy capacity for full-load condition in the event of puncture. Mooring loads for marine extra equipment shall be stated, so that they can be taken into consideration in other analyses.

7.6.2 Requirements for equipment for collection of dead fish

Equipment for collection of dead fish shall:

- have a user handbook and installation description;
- be designed so that its parts under no wave or current conditions lead to chafing on the net pen. If the design does entail danger of chafing, this shall be compensated for by a choice of material that withstands chafing, reinforcements, double protection or other solutions which do not lead to holes during the course of a normal operational cycle for the net pen;
- have recommended and maximum loads in air and water from the equipment for collection of dead fish in the net pen.

7.7 Requirement for stretch system for net pens

Equipment that stretches the net pen shall:

- be documented through calculations together with floating collar and net pen;
- have a user handbook and installation description which shall clearly state how the stretching system shall be assembled and disassembled;
- be attached so that energy from the equipment shall be handled in a proper manner without exceeding the dimensioning capacities of the main components;
- be designed so that its parts do not chafe against the net pen under any wave or current conditions. If the design nevertheless entails danger of chafing, it shall be compensated for by a choice of material which is resistant to chafing, reinforcements, double safeguarding etc. which do not lead to holes during the course of a normal operational cycle of the net pen.

7.8 Tests

Tests can be an alternative to analysis in order to document capacity. The tests shall take place in accordance with NS-EN 1990. Tests alone or combined with calculations are done to dimension marine fish farms or parts of them, or to find the characteristics of existing marine fish farms. Testing shall be carried out and evaluated as the basis for dimensioning of the marine fish farm installation with a sufficient reliability level based on the relevant limit state and dimensioning situation. Testing and testing conditions shall be representative for marine fish farms in operation.

Testing types are distinguished in order to:

- decide the use characteristics of a construction part or breaking capacity direct;
- find special material characteristics;
- reduce uncertainties in parameters in load or capacity models;
- control the quality of delivered products or uniformity in a production;
- be able to take into consideration factual circumstances which are observed during production;
- inspect the marine fish farm installation or main component after it is at the site.

7.9 Delivery

The main components and extra equipment shall be packed, transported to the site, stored, unpacked and moved at the site in such a manner that the equipment is not damaged or deteriorates.

7.10 Inspections of marine fish farms

7.10.1 General

A marine fish farm shall be inspected as a whole. Loads which are applied to various parts of an installation, depend on design of the floating collar, mooring, net, extra equipment and any raft. The following shall be done:

- an analysis shall be completed of the whole of the marine fish farm so that one finds which forces affect all parts of the installation. This analysis shall include the effects of mutual influence between the main components and extra equipment;
- capacity shall be checked in relation to the loads acting upon the installation. No main component shall have loads applied that exceed capacity. The limit states that shall be checked are those indicated in this Standard;
- completed analyses and capacity controls shall be documented.

Inspections to ascertain whether a marine fish farm is sufficient regarding strength shall be performed at the site. The main components shall not affect one another so that the capacity or tolerance limit of any of the main components is exceeded.

Relevant technical documentation specifying the main components and how they withstand environmental loads, as well as detailed planning, calculation and production procedures, shall be presented. As a main rule, relevant assumptions and limitations in the use of the equipment shall appear clearly in the user handbook for each main component. If not, it shall appear in the user handbook for the marine fish farm installation. Each of the following aspects shall be included in an assessment, in order of priority:

- the complete marine fish farm;
- each of the main components;
- assembly of extra equipment;
- secure placing of extra equipment in relation to the rest of the marine fish farm;
- technical specification of the main components.

7.10.2 Loads and interface between main components

Environmental loads which act on the main components shall be documented. Loads which the main components (mutually) act on each other under all conditions at the site shall be documented:

- force from rafts on the floating collar shall be within the tolerance limits for the latter;
- net drag from the net pen on the floating collar shall be within the tolerance limits for the latter;
- horizontal and vertical forces from the mooring on the floating collar shall be within its tolerance limits;
- the forces on the floating collar from the mooring shall not transfer moments to the floating collar that will damage it;
- horizontal and vertical forces from the floating collar on moorings, including additional forces from the net pen and raft, shall be within the tolerance limits of mooring, including the capacity of the bottom attachment;
- forces from the floating collar on the net pen shall be within the latter's tolerance limits under all wave and current conditions.

7.10.3 Dimensioning

Dimensioning shall be reviewed during the assessment and the documentation of the main components. Consideration shall be taken of extra loads one main component receives from the others, and it shall be established by calculations, research or modelling that each main component has the capacity to withstand these loads. The loads one main component is dimensioned to withstand from other main components shall be specified.

7.10.4 Composition of main components

The composition of main components shall primarily be based on the dimensioning, described in this chapter and in the chapters for the respective main components. In addition controls shall be performed of the following:

- Three-dimensional geometry of the main components shall be such that they do not cause chafing on any of the other main components;
- Materials in and protective coating on parts which connect the various main components, shall be such that they do not cause one another extra corrosion due to galvanic conditions;
- Connecting points between main components shall cause as little wear on adjacent equipment as possible;
- Connecting points between two main components shall be such that connection and disconnection is simple, at the same time as strength and reliability on the connecting function itself is sufficiently good;
- The main components shall be designed so that they do not complicate or impede inspection, maintenance, repairs, cleaning and replacements of other main components or parts of them;
- The composition of main components shall be in accordance with environmental loads such as they appear in the site survey.

7.11 Inspection of marine fish farms after installation at the site

It shall be established through assessment and documentation of marine fish farms at the site, that the main components and any extra equipment are suitable for each other, and that the marine fish farm can withstand the real loads such as they appear in the site survey.

An inspection of the completed installation of the marine fish farm at the site shall be performed. This inspection shall consist of the following at a minimum:

- checks that the marine fish farm installation and its main components are placed at the site as planned, and which all calculations are based on;
- checks that all bottom attachments are placed in accordance with the specifications;
- checks that all the parts are in accordance with the parts lists;
- checks that all the main components are connected in accordance with technical specifications;
- checks that the main components are undamaged after transport and assembly;
- checks that the user handbook is available for further daily operation.

This inspection shall be documented.

Manoeuvring of boats and placing of mooring attachments on the marine fish farm shall be assessed and documented in relation to construction and stability.

The placing of the total system shall be drawn in on a map with the placing of floating collar, any rafts, and mooring.

In the event of deviation between the planned marine fish farm after it has been placed at the site, an assessment shall be made and documented of whether a new analysis is necessary or not.

7.12 Operation

7.12.1 Requirements regarding daily operation

Operation shall take place in accordance with the user handbook as described in para. 7.14.

An operational procedure shall be available which describes activities that are relevant to escape in the operational phase, and which involves participants who do not usually work on the marine fish farm.

NOTE An operational procedure can include unloading of feed or slaughtering.

The procedure shall especially describe the voyage out to sea and mooring in the marine fish farm, in order to avoid damage to the floating collar, mooring or net pen. If necessary, corridors for voyages with vessels shall be defined.

There shall be a log to record actions and results of them, connected to daily operation, inspection, maintenance, tests and replacements, see para. 7.14.3.

The fish farmer shall assess the operational procedures annually and suggest any changes to them based on experience. Changes shall take place in co-operation with the supplier of the main components.

7.12.2 Requirements regarding inspection

Inspection shall be performed in accordance with an inspection programme based on the requirements in the user handbook. The inspection programme shall be divided into:

- routine inspections;
- functional inspections;
- sequential main inspections.

Routine inspections shall discover any faults or defects which are due to use, weather conditions, weakened parts, vandalism etc. Routine inspections shall be undertaken at fixed time intervals, such as daily, and before and after special occurrences, such as storms.

Functional inspections shall discover any weaknesses connected to the performance or stability of the equipment, particularly with regard to wear. Functional inspections shall be undertaken at fixed time intervals, such as monthly.

Sequential main inspections shall establish the level of the equipment in relation to function, stability, capacity and strength. This shall be in relation to weather conditions, visible signs of rot, modifications, replacements or impairment of weld seams, as well as all changes in the equipment's ability to withstand loads. All necessary disassembly or tests in order to complete this inspection shall be undertaken. Skilled persons shall be brought into this process if it is regarded as professionally justified and is specified in the user handbook. The main inspection shall be undertaken at fixed time intervals, such as semi-annually.

The intervals for inspection shall be determined on the basis of the characteristics of the components.

7.12.3 Requirements regarding maintenance and replacements

7.12.3.1 General

Routine maintenance shall take place in accordance with a separate maintenance plan on the basis of specifications in the user handbook. Corrective maintenance, repairs and replacements shall take place immediately when conditions that require it are discovered through the various types of inspection.

Maintenance, repairs and replacements shall take place in accordance with the user handbook.

7.12.3.2 Routine maintenance

Situations which shall be especially assessed and documented in connection with routine maintenance are:

- tightening of attachment points;
- painting and treatment of surfaces;
- lubrication of bearings;
- cleaning and removal of fouling;
- removal of destroyed or obsolete equipment;
- inspection and any maintenance of the site outside the marine fish farm itself.

7.12.3.3 Corrective maintenance

Circumstances which shall be especially assessed and documented in connection with corrective maintenance are:

- replacement of attachments;
- welding, inspection and maintenance of welds;
- replacement of worn parts or defective parts;
- replacement of load-bearing parts that are defective.

7.12.4 Criteria for when equipment is not of satisfactory quality

Criteria for when main components/components are not of satisfactory quality shall appear in the documentation for the components.

7.12.5 Changes and handling of changes

Changes to the marine fish farm which can increase the danger of escape, shall not be made before the necessary measurements, calculations, tests or modeling have taken place. These shall document that the change does not entail undesirable impacts.

This means changes which can lead to overrun of limits of planning, and can be:

- changed configuration of the marine fish farm;
- change of stretching system, such as increased lead weights;
- changed mesh length in the net pen;
- size and design of the net pen;
- extension of the number of cages on one mooring;
- turning of steel installations.

If an emergency change has been necessary, such as to salvage equipment or farmed fish as a result of an unforeseen event, the new situation shall be described as soon as possible based on measurements, calculations, tests or modeling. If the change has led to an unacceptable danger of escape, the acceptable situation shall be reinstated as soon as practically possible.

7.13 Requirements regarding product specification

7.13.1 Requirements regarding documentation of main components

7.13.1.1 Calculations

All calculations shall be available. Methods used shall be described, either directly or with reference to an authoritative document. Design working life which is used as a basis for the calculation shall be stated.

7.13.1.2 Material parameters

All material parameters in capacity, strength and dimensioning calculations shall be available and refer to the source (such as supplier documentation), or what reasoning, method or calculations they are based on.

7.13.1.3 Certificates for parts

All certificates for certified parts shall be traceable.

NOTE It will often be so that the fish farmer has certificates available for the main components, while the equipment supplier has certificates available for smaller parts.

7.13.1.4 Traceability

All parts shall be entered on a parts list which ensures traceability.

7.13.1.5 Documentation of production

The documentation of production of the main components shall contain at a minimum:

- documentation of raw materials, including product and material documentation as well as material certificates which specify the minimum breaking load, fatigue characteristics and any other characteristic values;
- documentation that the production processes, including proof that cutting, forming, etc., are done within given tolerance limits;
- documentation of connections, including that welding has been performed by certified personnel, that welding and heat treatment are based on recognised procedures, and that screws and bolts are tightened to the correct tension;
- documentation concerning surface treatment, including that grinding, sandblasting, lacquering and galvanising have been carried out in accordance with the correct procedures;
- documentation concerning installation, including that assembly of parts for a main component has been carried out within approved tolerances.

7.13.2 Drawings

7.13.2.1 Planning drawings

The following drawings shall be prepared for each marine fish farm:

- the arrangement drawings for the installation;
- placing of the area of use on nautical charts and detailed charts;
- mooring plan.

7.13.2.2 Construction drawings

The following construction drawings shall be prepared for a marine fish farm and its main components, where it is relevant:

- main construction and dimension drawings;
- detailed drawings of parts;
- attachment between main components.

7.13.2.3 Drawings for raft

The drawings shall include system drawings for ballast, draining, cooling water, fuel oil, compressed air/plant air, hydraulics, air and sounding, fire and hosing, to the degree it is relevant for the raft concerned. System drawings for electrical installation, including low voltage, shall also be available.

7.14 Requirements regarding user handbook

7.14.1 User handbook for marine fish farms

A user handbook shall be available for the marine fish farm. The handbook shall be a grouping of user handbooks for the individual main components, as described in para. 7.14.2. The handbook shall also include all the relevant circumstances which are not covered by the user handbooks for the main components, such as description of interface/connections between main components. Use and handling of extra equipment and procedures with relevance for escape shall be described. A user handbook shall be designed so that the main components can be replaced by other main components which satisfy the requirements in the user handbook without the necessity of further calculations.

A user handbook for marine fish farms shall have the following main chapters:

- key finds from the site survey;
- net pen;
- floating collar;
- mooring;
- raft;
- extra equipment.

The two last chapters contain only requirements for marine fish farms that have rafts or extra equipment. The same concerns other main components such as in the event of new construction types where certain main components are not applicable.

The contents of the handbook shall reflect the basic risk evaluation which is the basis for the individual main component, and for the marine fish farm installation and site as a whole. The handbook shall be formulated so that it contains as much traceability as possible, both for parts and their producer, important events and players concerned.

The language in a user handbook shall be simple, and difficult technical expressions shall be avoided. However, where they are used, they shall be defined. Theoretical descriptions and complicated explanations shall be avoided. The handbook shall describe the construction of the equipment and carefully considered and simple feasible solutions in as simple a manner as possible. Illustrations should be used where they shall contribute to simplifying the understanding of the construction and procedures.

The user handbook shall be revised at regular intervals or when significant changes take place. It shall form the basis for traceability and system for deviation handling.

7.14.2 User handbook for main components

7.14.2.1 General

A user handbook containing all main components shall accompany the installation. The user handbook shall be systematised under the following headings:

- producer and product identification;
- main component and its constituent parts;
- transport and storage;
- assembly;
- interface between other main components;
- operation;
- maintenance.

7.14.2.2 Producer and product identification

At a minimum there shall be a description of:

- factual information about the producer/supplier as well as contact information;
- identification of product/brand name/type/equipment/constituent parts;
- requirements for change, modification etc. in consultation with the producer.

7.14.2.3 The main component and its constituent parts

At a minimum there shall be a description of:

- necessary definitions to make the handbook unambiguous;
- drawings to ease assembly, operation and maintenance;
- traceability information;
- assumptions and limitations in the use of the equipment;
- greatest allowed loads and load distribution, both as direct environmental loads on the main component and as a load imposed by other main components;
- critical number of dead fish before it represents a danger of failure in the construction. Volumes of dead fish shall be indicated both as weight in the sea and weight in the air for the species of fish concerned;
- deviation: handling of errors.

7.14.2.4 Transport and storage

At a minimum a description shall be given of:

- requirements for how the equipment shall be packed, transported, unpacked, moved and stored;
- requirements for handling of equipment when loading and unloading;
- requirements for any towing with and without connection to the other main components, including maximum values for velocity, wind and waves;
- requirements regarding storage on shore.

7.14.2.5 Assembly

At a minimum this shall give a description of:

- circumstances which one must be aware of before the product is taken into use;
- qualification requirements for those undertaking assembly, such as in the form of welding certificates;
- assembly instructions for constituent parts in main components, including any sequence of assembly, space requirements and requirements as to weather conditions;
- requirements for any application of protection coating after assembly, such as to splices/welds;
- necessity for extra tools for assembly as well as the use of them, including removal of them after assembly;
- requirements regarding inspections/controls before fish are set out and in the operational phase;
- programme for inspection of marine fish farms, including functional tests, as well as inspection of completed work results which shall be especially inspected after assembly and launching, and how the inspection shall be performed.

7.14.2.6 Interface between extra equipment and between other main components

At a minimum a description shall be given of:

- assembly instructions towards other main components;
- limitations in choice and use of extra equipment and other main components including dimensions of and loads imposed by them, especially to avoid danger of chafing on net pens;
- interface between other main components, with specification of which loads one main component tolerates from other main components, including the greatest load (distribution) and angles of loads, distributed between any attachments points;
- possibilities and limitations in the use of mobile extra equipment;
- requirements and limitations for attaching and use of fixed extra equipment
- use of extra equipment, for instance, truck, and rules for it, such as connected to stability and the danger of heeling.

7.14.2.7 Requirements regarding operation of main components

Where it is relevant for a main component in relation to risk of escape, the following description shall be given:

- requirements regarding training of personnel;
- requirements regarding reception of boat;
- requirements regarding documentation of the size of the fish upon setting out;
- requirements regarding loading and unloading of live fish;
- requirements regarding calls and mooring of boats;
- greatest weight on and distribution of ice;
- procedures for normal handling and operation of main component;
- instructions for normal operational settings;
- requirements regarding cleaning/removal of fouling in sea;
- requirements regarding handling, including lifting and lowering;
- requirements for handling of special environmental conditions, such as drift ice, freezing over, icing or snow;
- description of how short-term, extraordinary loads which are imposed by feedboats, wellboats and other vessels, can be avoided.

7.14.2.8 Maintenance

General:

At a minimum a description shall be given of:

- requirements regarding planned maintenance, such as lubrication, tightening up of bolts, tightening of ropes etc.;
- overview of checkpoints and placing of them;
- overview of parts which shall be replaced, with given replacement intervals or requirements for remaining strength as well as procedures for replacement;
- criteria for when a main component as such shall be scrapped;
- requirements regarding testing, inspection and protection of equipment which is temporarily taken ashore;
- procedure for each type of inspection, such as whether it is visual inspection or NDT;
- plan for routine inspection with intervals for each type of inspection included, such as connected to welds, wear on protective coating, wear on load-carrying parts due to friction and degree of fouling;
- procedure for inspection and replacement after unforeseen events;
- procedures for handling and identification of spare parts, such as investigate of compliance with the producer's specifications;
- requirements regarding removal of obsolete parts and materials;
- requirements regarding removal of used parts.

Inspection programme:

All inspections shall be collected in a detailed inspection programme. At a minimum this shall include an overview of which types of inspection are required, at what times during the calendar year they shall be performed, and at what intervals they shall be performed.

The main philosophy of the inspection programme shall be that the person responsible for the daily operation shall also perform the necessary inspections. The handbook shall give clear rules for how an inspection that has been performed shall be entered into a log, or documented in another manner.

The inspection programme shall be based on a risk analyses. This means that the plan shall be directed towards the elements and parts which are most likely to fail, as well as the elements and parts that will result in the most serious impacts if they fail.

Procedures for inspection shall be so well described that competent personnel shall be able to perform them without access to other information than that given in the handbook. A description shall be given of what type of competence is required of personnel performing the various types of inspections.

At a minimum the following shall be included:

- inspection after change of a main component, any assembly of a new marine fish farm;
- inspection after change of a main component with impacts for other main components and the capacity of the whole of the marine fish farm;
- periodic inspections;
- inspections or testing for specially defined purposes or by specially defined equipment.

The inspection programme shall be related to the parts list. All parts in the overview shall be marked with what type of inspection they require, and how often this shall take place.

Maintenance plan:

All maintenance shall be described in a detailed maintenance plan. The maintenance plan shall at a minimum contain an overview of what types of maintenance are required, at which times they shall be performed during the calendar year, and at which time intervals they shall be performed.

The main philosophy of the maintenance plan shall be that the person responsible for the daily operation shall perform the necessary maintenance of the marine fish farm with its main components. The handbook shall give clear rules for how maintenance performed shall be entered into a log, or documented in another manner.

The maintenance plan shall be based on a risk analysis. This means that the plan shall be directed towards the elements/parts which will result in the most serious impacts if they should fail.

The maintenance routines shall be so well described that competent personnel shall be able to perform them without access to other information than that provided in the handbook. A description shall be given of what type of competence is required for personnel performing the various types of maintenance.

The maintenance plan shall be related to the parts list. All parts in the overview shall be marked with what type of maintenance they require, and how often this shall take place.

7.14.3 Log

During operation a separate log shall be kept which at a minimum shall include:

- action performed (type of inspection, maintenance or repair), with a reference to plan and procedure;
- result after action performed;
- necessary follow-up as a conclusion after action performed;
- date;
- person/institution performing the action;
- signature.

8 Requirements regarding net pens

8.1 General

The requirements in this chapter assume that one also knows the requirements in the other chapters in the Standard.

A net pen shall be suitable for the species it is to be used for.

8.2 Relationship to the floating collar

The net pen shall be suitable for the floating collar it is to be used in, and shall at a minimum have the number of attachment points to the floating collar in accordance with Table 10.

If the net pen is to be attached to the floating collar at points between the attachment points themselves so that it retains its planned three-dimensional design, and to prevent chafing between the floating collar and the net pen, these attachment points shall be so that they do not impose extra forces on the net.

NOTE A fastening rope with a considerably lower breaking strength than the net twine itself is used. The twine can also be reinforced.

8.3 Floating collar parameters

All characteristics of the net pen which can be of significance to the floating collar and planning of it, shall be specified. Including:

- number and placing of all attachment points;
- maximum allowed forces in the attachment points;
- total weight of net pen;
- solidity.

8.4 Requirements regarding the net pen which is to be used together with the stretching system

The net pen which is to be used together with the stretching system shall:

- be suitable for the floating collar and the stretching system it shall be used with;
- be designed so that it will under no wave or current conditions lead to chafing on the net pen. If the design nevertheless does entail danger of chafing, this shall be compensated for by the choice of materials which resist chafing, reinforcements, double safeguarding or other which will avoid holes during the normal operational cycle for the net pen;
- attachment points on the net pen shall be suitable for the stretching system, and the largest force shall be stated for each attachment point. Likewise, limitations in the direction of them shall be stated;
- the user handbook for the net pen shall clearly state how the net pen shall be stretched without risking chafing or other damage.

Analyses or tests shall document what loads the net pen tolerates from the stretching system. The loads tolerated by the net pen must be clearly stated in the user handbook or product information in the form of the greatest load on the attachment points on the net pen.

8.5 Use of environmental parameters

The calculations of the net pen shall at a minimum include a volume of fouling which gives up to 50 % increase of the twine diameter in the net pen as a whole.

The calculations of forces on the net pen caused by current shall include the dimensioning current velocity of the whole of the water column if no documentation is provided on varying current velocity at the relevant site. Net pens shall be calculated for the combination of environmental loads in accordance with Table 6.

8.6 Dimensioning principles

8.6.1 General

Dimensioning of net pens has traditionally been empirical design. This is the main principle in this Standard and assumes use of traditional materials for nets, twine and rope. The requirements are set out in Tables 8, 9 and 10. Other dimensioning principles can be used if it is documented that the intention of the Standard is satisfied.

8.6.2 Design working life in seawater

A net pen shall have a design working life of at least 36 months. This assumes that the net pen is used, inspected and maintained in accordance with the requirements contained this Standard, as well as the user handbook from the producer.

8.6.3 Determination of dimension grade

For sites with dimensioning, significant wave height lower than 2.5 metres and dimensioning current velocity of less than 0.75 m/s the dimension grade shall be determined on the basis of the net pen's circumference and the total depth in accordance with Table 8.

Table 8 – Dimension grades for net pens

Depth of net pen m	Circumference m							
	< 49	50-69	70-89	90-109	110-129	130-149	150-169	170<
0 – 15	I	II	III	IV	V	V	VI	0
15,1 – 30	II	II	IV	IV	V	VI	VII	0
30,1 – 40	III	III	IV	V	V	VI	VII	0
40 <	0	0	0	0	0	0	0	0

The net pen shall be suitable for the floating collar it is used with.

For sites with dimensioning, significant wave height over 2.5 metres the dimension grade is set at 0. For sites with dimensioning current velocity of over 0.75 m/s the dimension grade is set at 0.

8.6.4 Determination of dimensioning requirements

TWINE: For dimension grades I – VII in Table 8 the breaking strength requirements are set out in Table 9.

Table 9 – Dimension grades for and breaking strength of twine

Half-mesh ¹⁾ mm	Dimension grades							
	I	II	III	IV	V	VI	VII	0
Minimum mesh strength in net pen kg								
≤ 6,0	21	21	25	25	25	25	25	25
6,0 – 8,0	25	31	31	39	39	39	39	39
8,1 – 12,0	31	39	47	55	55	55	55	55
12,1 – 16,5	39	47	55	63	71	71	79	79
16,6 – 22,0	47	63	79	79	79	95	95	95
22,1 – 29,0	63	71	95	95	117	136	136	136
29,1 – 35,0	95	95	117	117	136	136	151	151

¹⁾ Half mesh in twine with square mesh shall be measured in accordance with NS-EN ISO 1107. With the use of twine with hexagonal mesh, the conversion table J.1 in Annex J shall be used.

Requirements regarding breaking strength in Table 9 are to be regarded as minimum requirements for twine in the production of new net pens.

Regarding net pens which are older than 24 months, it shall be documented that the twine has a strength of at least 65 % of Table 9. Twine in jump catch nets shall have at least 60 % remaining strength.

Requirements regarding ropes on net pens in accordance with dimension grade appear in Table 10.

Table 10 – Dimension grade requirements regarding ropes

		Dimension grades						
		I	II	III	IV	V	VI	VII
Minimum breaking strength all ropes		1900 kg	1900 kg	2800 kg	3400 kg	4100 kg	4100 kg	5000 kg
Top rope	Min. no:	1	1	1	1	1	1	1
Main rope	Min. no:	1	1	1	1	1	1	1
Bottom rope	Min. no:	1	1	1	1	1	1	1
Vertical rope/ attachment point	Max. distance:	7.5 m	7.5 m	6.5 m	6.5 m	5.0 m	5.0 m	5.0 m
Of which lifting rope	Max. distance:	15.0 m	15.0 m	19.5 m	13.0 m	15.0 m	15.0 m	10.0 m
Cross rope bottom	Requirements:	All lifting ropes SHALL continue as cross ropes at the bottom						

Vertical ropes include all vertical ropes. A lifting rope is a vertical rope that continues as a cross rope at the bottom. All lifting ropes shall be clearly marked. All lifting ropes, even though there are more than the Standard's minimum requirements, shall continue as a cross rope. The material factor is 3.0 for knotless rope and 5.0 for rope with knots.

With the use of a stretching system that can entail forces into the bottom of the net pen, all attachment points at the bottom rope shall continue as cross ropes.

Requirements regarding the number of attachment points between the floating collar and net pen in accordance with the dimension grade appear in Table 10.

The crossing point between the vertical rope and main rope (at the waterline) is the attachment point for the net pen. The greatest load from the stretching system shall be stated.

8.6.5 Net pens in dimension grade 0

8.6.5.1 General

The following procedure shall be used in calculations and inspections of net pens that do not fall under the requirements in Tables 9 and 10, or that fall into dimension grade 0 in accordance with Table 8:

Inspections shall be made to check that the strength of the twine and framework (rope) has sufficient strength and integrity to tolerate loads during use and handling as well as the environmental forces which can be imposed at the relevant site. Twine and rope shall have a strength which is greater than or equal to the requirements regarding strength in Grade VIII given in Table 9 and Table 10.

8.6.5.2 Planning

Net pens in dimension grade 0 shall be planned in relation to the floater and stretching system by calculating forces which occur in the net pen and comparing to capacity.

Loads in Chapter 6 shall be imposed on the system, and the forces in twine and rope shall be found. For rope in the net, material factors in accordance with para. 8.6.4. shall be used, and the mesh strength for twine is found in Table 9.

8.6.5.3 Assessment of reinforcement of certain parts of the net pen

Net pens in dimension grade 0 shall be assessed reinforced in the following manner:

- the probability for chafing damage to the net pen at the waterline shall be assessed and the twine protected or reinforced if necessary;
- necessary reinforcement of the net construction as a whole shall be based on the site and operational requirements;
- net reinforcement of both the side and bottom of the net pen in the area against the bottom rope, in accordance with para. 8.7.

For documentation of strength in a net pen, Annex E shall be used as far as it is applicable.

8.7 Requirements for design

Net pens shall be made of twine and ropes which satisfy the following:

- the net pen shall be constructed in accordance with the dimension grades in Tables 8 – 10, based on the net pen's size and strength requirements regarding mesh and ropes;
- the net pen shall be assembled so that forces are transferred through ropes attached to twine, and the rope shall, during the whole of the design working life, have less extension (elasticity) than the twine used;
- lifting ropes shall tolerate the load when the net pen is lifted such as it is specified in the user handbook;
- the net pen shall be produced without tears and shall be inspected for this after production;
- splices shall not reduce strength significantly;
- for net pens in dimension grade III and higher, the bottom shall be reinforced with double twine, at least 0.5 m into the bottom and 0.5 m out to each side of all vertical ropes that are not lifting ropes or equivalent reinforcement;
- the bottom shall be constructed so that it stands taut and ensures that dead fish are collected in the dead fish scoop when the bag is stretched in accordance with the user handbook;
- areas at the bottom of the net pen, where a dead fish scoop is used, shall be reinforced with double twine or equivalent.

When cutting twine and assembling net parts, the following requirements shall be satisfied:

- with hand sewing on twine with a half-mesh size less than 25 mm, the thread(s) shall be threaded through each mesh and knotted at a distance of maximum 12 cm;
- with hand sewing on twine with a mesh size of 25 mm half-mesh or larger, the thread(s) shall be threaded through each mesh twice and knotted at a distance of maximum 12 cm. Secure knots shall be used;
- with machine sewing, stitching shall be done twice over the splice on the twine to avoid unravelling. Start/stop of the seam shall be properly secured to avoid unravelling.

Assembly:

- with hand sewing on twine with a half-mesh size less than 25 mm, the thread(s) shall be threaded through each mesh and knotted at a distance of maximum 12 cm;
- with hand sewing on twine with a mesh size of 25 mm half-mesh or larger, the thread(s) shall be threaded through each mesh twice and knotted at a distance of maximum 12 cm. Secure knots shall be used;
- with splicing the lacing thread one secure knot shall be used.

When lacing net pens (attachment of rope to twine) the following requirements shall be met:

- when lacing /attachment of rope to twine it shall be ensured that the twine is sufficiently slack and is evenly stretched. It shall also be ensured that the rope takes the strain, and not the twine. Net parts shall be joined before rope is laced;
- all lacings shall be on the outside of the net pen unless special functional requirements require attaching on the inside;
- the seam between the rope and twine (the lacing) shall have a breaking strength of at least the same level as the twine;

- when lacing by machine the rope shall be sewn to the twine consecutively, in relation to the first stretch point in this overview. Start/stop of the seam shall be properly secured against unravelling;
- when lacing rope to net pens with a mesh size of less than 15.5 mm half-mesh the thread(s) shall be wound over the rope and twine through every second mesh, and there shall be a maximum of 12 cm between each attachment point (knot). There shall be at least three hitches or equivalent secure knots per attachment point (knot);
- when lacing rope by hand to net pens with half-mesh sizes of, or greater than 15.5 mm, the thread(s) shall be wound over the rope and twine through each mesh, and there shall be a maximum of 12 cm between each attachment point (knot). There shall be at least three hitches or equivalent secure knots per attachment point ((knot/clamp knot) if lacing is done by hand.

8.8 Materials

8.8.1 General

By materials is understood filament, twine, fibre and rope used in the making of net pens. The materials shall be in accordance with documentation provided by the producer, and shall be of such quality that they meet the requirements set out in this Standard. The producers shall provide documentation indicating producer, trade name, type of material, characteristics and marking of the product. The characteristics shall appear as the result of documented tests.

Material factors for rope in net pens shall be set in accordance with para. 8.6.4.

8.8.2 Filament

The following requirements regarding characteristics of the filament yarn shall be documented through tests:

- the filament yarn shall have the characteristics which make it suitable for meeting the requirements made for the completed net pen;
- the filament yarn shall be protected against UV radiation. Protection shall be sufficient in relation to a design working life of at least 36 months;
- only certified filament yarn shall be used. The chemicals used for treatment of filament yarn and rope, and which can affect the strength of the net pen, shall be specified. All relevant parameters connected to the strength and characteristics of the net pen shall be documented.

8.8.3 Twine

Twine shall be produced from filament which meets the requirements set out in para. 8.8.2.

It shall be documented through tests that the twine's strength characteristics satisfy the following requirements:

- knot strength shall be measured with an overhand knot in accordance with NS-EN ISO 1805 and NS-EN ISO 1806;
- elongation at break shall be satisfactory for the product it is to be used in;
- twine used in knotted nets shall have characteristics suitable for the knot and the finishing process which is necessary for good knot strength;
- when determining twine diameter and appurtenant solidity, the basis shall be the relationship between the projected twine area and total area of the net panel;
- the twisting degree shall be such that the twine is balanced.

8.8.4 Net pens

Twine for use in net pens shall be manufactured of twine or filament that satisfies the requirements stated in para. 8.6 and Table 9. As net for fish farming purposes both knotted and knotless net can be used.

The following requirements are made regarding net:

- during the whole of the design working life it shall possess an elasticity which is greater than the rope that is used in the net pen;
- net and rope shall not shrink so that forces are transferred from rope to net ;
- testing of net shall be carried out in accordance with NS-EN ISO 1806;
- it shall be documented that the net satisfies the requirements laid down by the Standard.

8.8.5 Rope

Rope for use in net pens shall be produced from filament that satisfies the requirements in para. 8.6 and Table 10. The following requirements are made regarding rope:

- during the whole of the design working life it shall possess an elasticity which is less than the net which is used in the net pen;
- testing of rope shall be performed in accordance with NS-EN ISO 2307;
- it shall be documented that the rope satisfies the requirements laid down by the Standard.

Mixed polyolefine rope shall also satisfy the requirements in NS-EN 14687.

8.8.6 Other materials

Other materials can be used if it is documented that at a minimum they satisfy the functional requirements in this Standard.

8.8.7 Controls of materials

In all deliveries of materials, the producer shall control and confirm:

- that the delivery is in accordance with the order;
- that the producer's routine tests confirm that the characteristics of the product are in accordance with those that are stated;
- that the net pen is produced from materials in accordance with this Standard.

Control of materials for net pens produced and repaired according to this Standard with regard to material quality, material use, dimensions, and production shall be documented.

8.9 Operation and maintenance

8.9.1 General

Operation and maintenance shall take place in accordance with the user handbook. The design requirements in para. 8.6 apply to new and used net pens.

After 24 months, a net pen shall have a valid service card as an attachment to the certificate for the dimension grade the net pen is certified for. The service card can have a period of validity of up to 24 months. A net pen shall not be taken into use before a valid product certificate or service card has been received. A service card shall always show the quality of the net pen. The service card shall provide information regarding the condition of the net pen and period of validity by showing the last date for use in seawater.

Handling of the net pen shall be planned so that it only takes place in the period of weak current. Handling of the net pen in strong current shall only take place in emergency cases, and great care shall be shown.

8.9.2 Lift and tow

In the event of towing where the net pen is connected to the floating collar, the velocity shall never exceed the relative velocity of the net pen in relation to the water masses which are identical to the maximum current the net pen is certified for.

Lifting of the net pen by the mesh shall never take place, it shall only take place by the use of lifting ropes, and then in such a manner as to avoid unequal loads on the net pen.

8.9.3 Requirement regarding service station

A service station shall at a minimum have the following documented:

- knowledge and understanding of the net pen's design and function, with appurtenant material qualities;
- documented requirements regarding design of the service card with appurtenant ID marking on the net pen, and archive which provides the possibility of traceability;
- suitable area for inspection and handling of the net pen;
- procedure for reception and delivery of net pen;
- procedures for a testing programme of the net pen with suitable tools and documentation of results;
- procedures for various repairs, mending net pens, and replacement of twine.

8.9.4 Inspection and repair of net pens

Service cards that confirm that inspection and maintenance have been performed in accordance with the user handbook, and that the net pen satisfies the requirements set forth in the Standard, shall only be issued by a service station that meets the requirements set out in para. 8.9.3.

Net pens which do not meet the requirements for remaining strength in twine as described in this Standard, shall no longer be used for fish farming.

The log from the history of the net pen shall be made available to the service station that performs inspection and testing.

Attachment points shall be inspected, and all ropes shall be examined, assessed and documented with regard to chafing and wear. In addition, stretch tests shall be performed of the twine with suitable tools. Regarding stretch tests the requirements in NS-EN ISO 1806 shall be used as far as they are applicable. The net pen shall satisfy the requirements regarding breaking strength as they appear in Table 9, in order for the net pen to be issued a valid service card.

At least 9 stretch tests shall be performed on the sides of the net pen. The tests shall be distributed evenly around the net pen with 3 stretch tests on the jump catch net, 3 stretch tests just under the main rope and 3 stretch tests at half the depth. In addition, at least 3 stretch tests shall be taken evenly distributed over the bottom. In dimension grades VII and 0 the number of stretch tests shall be doubled. It shall be stated whether the twine has been tested under wet or dry conditions.

Stretch tests of twine shall be performed before any anti-fouling etc. is performed on the net pen.

The chemicals that are used to treat the net pen, and which can affect the strength and characteristics of the net pen, shall be specified.

A service card shall be issued for inspection, stretch tests and repair of the net pen. This will, together with the product certificate, be the documentation that the net pen still satisfies the requirements of the Standard.

8.9.5 Period of validity of the service card

A service card can have a period of validity of up to 24 months' use. This applies as long as the strength of the twine is 100% or more in relation to the dimension grade in Table 9. When the remaining strength of the twine is between 100 % and 65 % of the requirements regarding breaking strength (between 100% and 60 % for the jump catch net), the service card can have a period of validity of up to 12 months. In special cases, where the validity of the service card expires before the net pen is taken up, the service station can assess whether a further 3 months' extension of the period of validity can be given on the basis of the net pen's documentation as well as visual assessment of the net pen. This shall be documented.

The validity period of the service card starts when the net pen is lowered into the sea, but maximum 12 months after the date of issue. This assumes that the net pen is handled and stored in accordance with requirements in the user handbook. This shall be documented in accordance with para. 8.10.1. A possible extension may only be allowed in cases where there is greater risk of fish escaping when the net pen is changed in this phase, than by an extension of the period of validity by up to 3 months at a time for a net pen of expected good quality.

The last valid service card should be available and present for the service station that is to perform service on the net pen. At a minimum, a service card shall contain:

- ID number of the net pen;
- measurements of the net pen cage;
- dimension grade and requirements for strength;
- materials and dimensions for twine and rope;
- the result of stretch testing with the basis in requirements;
- description of maintenance performed;
- date of issue and period of validity;
- service performed in accordance with NS 9415 or equivalent.

NOTE A service card shall be retained together with the log, see 7.14.3.

8.10 Requirements for documentation

8.10.1 Materials and processes

Documentation of material quality, material use, dimensions, production and repair of each net pen shall be in accordance with the Standard's provisions and shall be stored for any subsequent inspection and documentation.

Documentation of own inspections performed shall be stored in a systematic manner in order to ensure traceability. At a minimum the documentation shall include:

- a copy of all material orders accompanied by documentation, control report from receipt, marking of materials and reports from any testing of materials from this delivery;
- control report from any own production of twine, rope and net;
- copy of documentation of any own-produced twine and net, as well as that supplied by others;
- copy of documentation of net pen shall accompany the service card.

8.10.2 Planning

At a minimum the following shall be documented for planning of the net pen:

- assembly sketch of the net pen, including jump catch net, with all the relevant measurements shown;
- all allowed net designs, sizes and stretching systems or mooring lines attached to the net pen;
- choice of materials and dimensions for the various parts, including twine diameter for rope and net;
- twine number, mesh length, mesh type, rope type and size of the mesh in the form of a half-mesh in accordance with NS-EN ISO 1107;
- which functional requirements shall be met;
- description of any redundancy.

8.10.3 Design

In connection with the design of net pens the following shall be documented at a minimum:

- purchased raw materials, including requirements regarding the suppliers of material certificates which specify the minimum breaking load, shrinking characteristics, ageing characteristics, UV resistance and any other characteristics for the relevant raw material or part;
- that the production processes such as knotting, splicing, sewing and binding are performed by personnel with the necessary competence or under the supervision of personnel with the necessary competence. Competence shall be documented;
- that the production processes such as impregnation are performed with substances/chemicals recommend in accordance with provisions given by the authorities/suppliers;
- that the assembly of the various parts for one component is done within stated tolerances and with the indication of assembly lacquer;

8.10.4 Marking

Net pens shall be marked by the producer. Marking shall be permanently attached to the top rope, and shall be clearly visible and legible for the duration of the design working life of the net pen. The net pen shall have at least two permanent labels, of which at least one shall be attached to the top rope. The label shall be designed and attached so that it does not lead to chafing of the net pen.

In packing and transportation of net pen, the marking should be well visible.

The producer of the net pen shall store an overview of numbers for product documentation which is issued, and to whom the delivery was made.

8.10.5 Documentation which shall accompany the product: Product documentation

Net pens which are delivered in accordance with this Standard, shall be delivered with product documentation from the producer. Product documentation for the net pen shall specify a design working life of 36 months and thereafter as long as it is documented that inspection and maintenance have been performed and that the net pen is in accordance with the requirements of the Standard.

The product documentation shall at a minimum contain the following information:

- producer;
- date of issue and period of validity;
- number of product documentation;
- measurements of the net pen;
- dimension grade;
- size of mesh in the form of half-mesh in accordance with NS-EN ISO 1107;
- species of fish for which the net pen is intended;
- materials and dimensions for net and rope, including reinforcements;
- recommended and greatest force imposed by the stretching system;
- confirmation that the net pen is in accordance with the order, and that it is produced and controlled in accordance with the requirements in the Standard;
- reference to user handbook for the net pen;
- reference to any enclosures to the product documentation;
- that the information in the product documentation is only valid as long as the requirements in the user handbook and this Standard are complied with.

NOTE The specifications of design working life in the product documentation start from the time of lowering the net pen into the sea, but no longer than 12 months after the date of issue. This assumes that the net pen is handled and stored in accordance with the requirements in the user handbook.

In special cases, where the product documentation's period of validity expires before the net pen is taken up, the service station can assess whether a three-month extension of the period of validity can be granted on the basis of the documentation for the net pen, as well as visual assessment of the net pen. This shall be documented.

9 Requirements regarding the floating collar

9.1 General

The requirements in this chapter assume that one also knows the requirements in the other chapters in the Standard.

9.2 Planning

Floating collars shall be dimensioned in accordance with para. 7.3.

9.3 Mooring parameters

All characteristics of the floating collar which can be relevant to mooring and planning of it, shall be specified. Hereunder:

- requirement regarding pre-tensioning. This shall be defined where it is relevant;
- number and placing of all attachments points;
- maximum force and three-dimensional direction for relevant points. Largest angle size at attachment of crowfoot shall be stated where it is relevant in order to avoid unequal load on the clamps or railing supports;
- maximum allowed moment from moorings, where it is relevant.

NOTE The greatest strain on the floating collar is normally applied through the mooring system. The variations in the different forces and line characteristics can impose great loads. This concerns large, marine fish farms, i.e. long platform installations, in particular. Here several lines run parallel. In such a case it is especially important that the floating collar does not have too great local or global loads imposed.

9.4 Net parameters

All characteristics of the floating collar which can be of relevance to the net pen and planning of it, shall be specified. Hereunder:

- number of net suspension points for the stretching system with placing, capacity and specification. The net suspension points shall be placed so that all vertical ropes in the net pen can be attached to the floating collar;
- load effects from the net pen, normally net depth;
- greatest total net weights;
- how fouling is taken into consideration when forces on the net pen are calculated, solidity including fouling shall be stated.

NOTE Usually, 50% increase of the twine diameter is used so that solidity shall include fouling.

9.5 Requirements regarding floating collars which are used together with stretching system

Floating collars which are used together with a stretching system shall:

- be suitable for the stretching system it is to be used with, so that the stretching system does not lead to chafing of the net pen under any type of wave or current conditions. If the design nevertheless does entail a danger of chafing, this shall be compensated for by the choice of material which resists chafing, reinforcements, double safeguarding etc. which means that holes are avoided during the net pen's normal operational cycle;
- describe in the user handbook how the floating collar and stretching system shall be assembled together in order to avoid chafing or other damage to the relevant net pen.

9.6 Requirement regarding construction parts

All construction parts in the floating collar shall be able to absorb forces imposed. The construction parts shall be able to absorb forces from loads on the part and loads from adjacent parts, including mooring, net pen, feed dispensers and other equipment.

There shall be calculated and documented that connections such as welds, bolts or hinges have the necessary capacity to transfer forces. Materials which wear more quickly than the rest of the construction, such as washers, shall be inspected and replaced when the wear tolerance has been exceeded. Requirements regarding this shall be stated in the user handbook.

All construction parts in the floating collar shall be marked in such a manner that there is good traceability in relation to the design and purchase of the single parts.

The floating collar shall be constructed such that:

- it is simple to install net pen and bird net. Placing of attachment points shall comply with the requirements regarding net pens, see Chapter 8;
- there is no chafing on the net pen;
- it is easy to keep clean;
- it is easy to keep clean in seawater;
- it is easy to install any extra equipment;
- there are no hollows etc. where liquids and shells can collect.

9.7 Requirements relating to welds and welder

All welds in metal shall be performed in accordance with approved procedures (WPS) as indicated in NS-EN ISO 15607 and NS-EN ISO 15609-1, NS-EN ISO 15614-1 and NS-EN ISO 15614-2. All welders shall possess an approved certificate in accordance with NS-EN 287-1 and NS-EN ISO 9606-2. Welding co-ordination shall be in accordance with NS-EN ISO 14731. The testing and quality plan shall be drawn up in co-operation with an approved welding co-ordinator and inspector in accordance with NS 470.

All welds in plastic shall be in accordance with NS 416-2, Annex C. Certificate of plastic welders shall be in accordance with NS 416-1.

9.8 Installation and repair

Correct and suitable welding equipment shall be used. Certified welders shall be used for installation and repair of vital parts.

Installation shall be undertaken during favourable external conditions, i.e. that the weather situation is such that installation takes place in accordance with regulations. The technician shall at all times ensure that the external conditions are satisfactory to perform proper installation.

9.9 Specification of floating collar for towing

The following documentation shall be prepared for towing:

- plan for attachment of towing hawsers and auxiliary system for towing;
- maximum towing velocity and allowed wave and wind loads when towing is in progress;
- controls that damage has not occurred after towing has been completed.

9.10 Special requirements for steel installations

9.10.1 Strength calculation

Strength calculation of marine fish farms shall be documented. Based on information regarding loads, the following calculations shall be performed:

- global strength analysis, including the forces from mooring;
- local strength analysis;
- fatigue analysis.

Local analysis of construction parts of steel shall be performed in accordance with NS-EN 1993-1-1.

9.10.2 Materials

Requirements regarding material factors shall be in accordance with NS-EN 1993-1-1 and safety factors in accordance with NS-EN 1990. Material factors for steel installations shall be in accordance with Table 11. The capacity of the material shall be regarded as given by the yield strength.

Table 11 – Material factors for steel installations

Limit states	Parameters	Material factor
Breaking strength	Cross-section capacity	1,1
Breaking strength	Screw, bolt, friction and welding connections	1,25
Fatigue limit	All material factors	1,0
Accident limit	All material factors	1,0

Assessment and documentation of screw and bolt connections shall be performed. This includes an assessment and documentation of capacity of bolts, screw shanks, hole edge, ripping out of the basic material and cracks in the basic material.

9.10.3 Fatigue in parts of steel

A fatigue calculation shall be performed for all critical parts. Loads which vary in the wave frequency area shall be taken into consideration.

The fatigue analysis shall be performed in accordance with NS-EN 1993-1-1.

Regarding installations having dimensions within limits where experience data is found, a simplified fatigue analysis based on Weibull distribution can be performed. The Weibull factor shall then be set at 1.0 unless another distribution can be documented. The danger of natural frequencies in the construction shall be assessed and documented, and natural frequencies shall be taken into consideration in calculations in relation to design working life. The starting point shall be 20 years' design working life in the event of fatigue.

9.11 Special requirements for flexible marine fish farms

9.11.1 General

By flexible fish farm installations is understood in this Standard to be marine fish farms produced of polymers, first and foremost plastic. Certain sequences can also be relevant where rubber is used as material.

Dimensioning shall take place for all relevant limit states, and the loads and load combinations, load factors and material factors that are used shall be stated. The loads, load combinations and limit states used during dimensioning shall also be stated.

The capacity of a plastic pipe shall be regarded as exceeded in one of the following events, whichever occurs first:

- flow occurs in the cross-section;
- local cracking occurs in the cross-section.

9.11.2 Planning and development

9.11.2.1 Calculation of strength of the plastic installation

Stresses in the plastic floating collar shall be calculated based on the equipment's geometry, natural frequency situation and external forces. For this purpose, the classic formulas or FEM analysis shall be used according to the following principles:

- in the event of small displacements and/or unchanged geometry or linear visco-elasticity, classic formulas shall be used;
- in the event of non-linear material deformation and/or large geometrical changes, non-linear FEM analysis shall be used.

Calculation of strains, displacements and danger of cracking shall be performed based on the material's visco-elastic characteristics (elastic factors, E_{sig} , E_{rel} , etc.).

In the event of strong anisotropy, first and foremost in reinforced plastic, consideration shall be paid to the material's visco-elastic characteristics in the calculation of strains, displacements, danger of cracking and breaking.

The aim during planning of floating collars of plastic shall be to keep the shear stresses low by avoiding great concentrated loads or surface pressure.

In the event of combined stresses the following breaking hypotheses shall be used:

- danger of brittle fractures: normal stress hypothesis
- danger of ductile fractures: shear stress hypothesis

The requirements regarding allowed strength loads in plastic installations shall be in accordance with the stretch and shear strength data for the various materials, and shall be obtained from the plastic producer's supplier documentation. Requirements in relation to assessment and documentation of shrinkage in the construction shall be set based on typical values for allowed stretching and stresses, as indicated in the plastic producer's supplier documentation. Further calculation of this, where the stress time, temperature and type of force (stress condition, static or dynamic situation, environmental conditions etc.) shall be included, shall be performed based on the supplier data based on material tests.

The strength characteristics of the installation, especially in relation to long-term loads, shall be documented.

The material factor for plastic shall be set at 1.25 for ultimate limit state and 1.0 for accident limit state.

9.11.2.2 Local cracking

Local cracking in plastic pipes usually occurs where the pipes are exposed to extensive bending forces, such as in areas with locally concentrated loads. If the capacity for cracking is less than for flow, the crack capacity shall be dimensioning.

Cracking is calculated as follows:

$$F_e = 0,5 t \cdot D^{-1} \cdot E$$

where:

F_e = cracking stress;

t = thickness of pipe wall;

D = diameter of pipe;

E = elasticity module.

9.11.2.3 Dimensioning of plastic against fatigue (danger of brittle fracture)

Fatigue shall be assessed and documented for all plastic materials which are exposed to high and varying stresses. This shall be seen in connection with cracking processes which result in brittle fractures with static stretch forces.

Assessment and documentation of fatigue shall take the following conditions into consideration:

- increasing temperature leads to less fatigue strength;
- thick-walled pipes lead to quicker fatigue fractures because of potentially strong temperature increases;
- fatigue is a result of frequency and high strain.

9.11.2.4 Use of polyethylene

Characteristics for pressure pipes of polyethylene shall be in accordance with NS-EN 12201-2.

All material which is used, shall be UV stabilised in accordance with NS-EN 12201-2

9.11.2.5 Production

9.11.2.5.1 Control of production of pipes

Production of pipes shall be in accordance with NS-EN 12201-2.

9.12 Special requirements regarding combined marine fish farms

For combined marine fish farms, such as marine fish farms where rafts together with floating collars form a unit (the raft is integrated in the floating collar), the same characteristics shall be able to be documented with regard to escape, such as strength, stability and buoyancy capacity, as for rigid, articulated and flexible marine fish farm installation. The movement characteristics for the raft module against the floating collar shall be documented

9.13 Special requirements regarding other types of floating collars

For other types of floating collars, full documentation is required for all measurements, calculations, tests and simulations. Risk and safety levels shall be the same as for steel installations and flexible installations

9.14 Requirements regarding documentation

9.14.1 Requirements regarding documentation of the floating collar's planning and production

At a minimum the following documentation shall be available:

- assembly sketch of the floating collar with all relevant measurements drawn on;
- specification of which functional requirements shall be met;

NOTE This can e.g. be whether it is possible to drive a truck on the floating collar, or the size of boat which can come alongside it.

- description of any redundancy;
- description of the environmental loads which the floating collar shall tolerate, at a minimum loads from wind, current, waves, temperature, ice and snow;
- description of the functional loads which the floating collar is dimensioned for, particularly connected to direct operation of the marine fish farm installation, such as load from equipment, feed, personnel, etc.
- description of the permanent loads on the floating collar in the form of weight/buoyancy, and the distribution of them on the collar;
- description of accidental loads, such as negative loads because of breaks in the mooring lines and loss of buoyancy;

- maximum weight and distribution on ice;
- indication of limit conditions which are assumed, in the form of size, weight, solidity of the net pen, maximum net pen drag and attachment of the net pen to the floating collar;
- description of the mooring system, at a minimum the number of lines, pre-tension, rigidity of the mooring system, and how the lines shall be led in and attached to the floating collar;
- indication of mooring line forces, such as maximum allowed load on the mooring lines with regard to both the whole of the marine fish farm installation, and each attachment point, as well as maximum allowed vertical force with regard to drawing down of the marine fish farm installation;
- design working life.

9.14.2 Marking of floating collars

All floating collars shall be supplied with an identification plate located in a well visible and easily accessible place.

The identification plate shall contain the following information:

- satisfaction of the requirements in this Standard;
- circumference;
- highest wave and current exposure;
- maximum load;
- any drivable axle load;
- design working life;
- date of production;
- journal number;
- order number or project number;
- producer.

EXAMPLE NS 9415, maximum wave height: 1.5 m, max. current 1.0 m/s, maximum load 50 tonnes, drivable axle load 4 tonnes, 20 years' design working life, 2003-03-17, journal number 0001, order number 68745, name of producer.

The identification plate shall accompany the floating collar for the entire design working life, including after changes and modifications. All modifications and repairs shall be logged and referenced against the number on the identification plate.

9.14.3 Assembly/repair log

After assembly is completed an assembly log shall be kept which confirms that the assembly has been performed in accordance with the order and in accordance with this Standard. The log shall show the journal number, order number and production date for each part. It shall be signed by the responsible technician. The same applies to repair work. Together with the identification plate, the log shall facilitate traceability in regard to applicable requirements.

10 Requirements regarding rafts

10.1 General

The requirements in this chapter assume that one also knows the requirements in the other chapters in the Standard.

10.2 Planning

10.2.1 General

Dimensioning of rafts shall be suitable for the material from which it is made, as well as the loads which occur for this type of vessel.

In general, dimensioning shall deal with the raft's global strength capacity as well as local strength, particularly for the attachment points towards other main components, such as mooring.

The superstructure shall be dimensioned for loads from waves which could occur at a site. It shall be documented that hatches, doors and windows shall satisfy the same requirements. Alternatively, it shall be documented that the buoyancy capability of the raft is present after water penetration has occurred.

Maximum load for the raft shall be stated.

10.2.2 Dimensioning of steel rafts

Dimensioning shall take place in accordance with recognised methods, such as NS-EN 1993-1-1.

NOTE Other examples of recognised methods are described in the rules laid down by ships' classification companies.

The results of dimensioning shall appear on a profile and plan drawing where all dimensions shall be stated. Further, the following documentation shall be prepared as a basis for production:

- profile, plan and section giving dimensions of parts;
- welding table specifying welding details and subsequent inspection of welding joints with the use of NDT.

Dimensioning waterline in calculations shall be in accordance with the calculated maximum draught. The raft shall be dimensioned according to which of the following two criteria gives the highest requirements regarding the parts:

- the dimensioning waterline shall be used, and reinforcements in the bow and stern shall be ignored;
- bow and stern are calculated with the draught equivalent to a light ship condition.

10.2.3 Dimensioning of rafts of concrete

The dimensioning basis and use of materials shall meet the following requirements:

- reliability Class 2, medium impacts in the case of failure in accordance with NS-EN 1990;
- planning control in category normal in accordance with NS-EN 1990.

Dimensioning shall also take place in accordance with NS-EN 1992-1-1, with the following material factors and exposure class:

- the material factor γ_m is set at 1.40 for concrete, and γ_m is set at 1.25 for reinforcement;
- the exposure class shall be XC3 in accordance with NS-EN 1992-1-1.

10.2.4 Dimensioning of rafts of other materials

Dimensioning shall be performed in accordance with recognised methods.

In the use of recognised methods for strength calculation of the relevant material, the raft's strength capacity shall be documented for all construction parts when adding the above-mentioned loads.

10.2.5 Foundations for extra equipment

The foundations for equipment with unladen weight or a load of over one ton shall be documented in separate calculations. Further, a drawing shall be available of such foundations with an added capacity for appurtenant equipment.

10.3 Stability

10.3.1 General

Here it must be distinguished between intact stability and stability in the event of damage. Stability shall be documented with the aid of calculations. Heeling tests shall be performed in order to verify the placing of the centre of gravity, as well as light ship weight. For serial productions, the heeling test can be dropped if it can be documented that the light ship's weight does not deviate more than 5% from the tested example, and that no changes have been made which can affect the placing of the centre of gravity. Heeling tests can be dropped if it can be documented that:

- the type of construction does not allow a heeling test to be performed;
- the stability is calculated with an adequate margin;
- placing of the centre of gravity and light ship's weight is determined with certainty in another manner.

10.3.2 Intact stability

In the event of intact stability, the raft shall meet the following minimum requirements:

- The area under the GZ curve from 0.00 degrees to the righting arm at a maximum, shall not be less than 0.08 m-rad;
- 0.05 m-rad is used if the raft is unmanned or the raft shall only be placed at a site with dimensioning, significant wave height equivalent to 2.0 m. By an unmanned raft is meant a vessel where there are no arrangements for overnighing;
- Static heeling caused by an evenly distributed load of 0.54 kPa (equivalent to a wind velocity of 30 m/s), shall not exceed a heeling angle equivalent to half the freeboard in the relevant conditions. The arm in the wind element shall be measured from the centre of the area on which the wind acts to half the draught;
- GZ shall be positive to 15 degrees as a minimum.

At a minimum, and where it is relevant, these requirements shall be verified for the following conditions:

- light ship
- light ship with full water tanks and diesel tanks;
- fully laden with the intended type of load;
- half-laden with the intended type of load.

If the raft is intended to operate in seas where there is danger of icing, this shall be clearly stated. Loads from ice in calculations shall be obtained from para. 5.5. At a minimum, and where it is relevant, the following conditions shall be verified:

- light ship with load from ice;
- light ship with full water tanks and diesel tanks as well as load from ice;
- fully laden with the intended type of load as well as load from ice;
- half-laden with the intended type of load as well as load from ice.

The calculation shall show the raft's maximum draught and trim area. Instructions shall be given in the user handbook regarding allowable load distribution. Instructions for allowable load distribution shall be posted on board and published to the relevant users.

Beyond this, it shall be assessed and documented whether there is a requirement to investigate special conditions adapted to the individual construction.

10.3.3 Damage stability

Under the freeboard deck the raft shall be divided into three or more watertight sections. These shall be arranged so that the raft in the event of the puncturing of a random watertight section shall still retain sufficient buoyancy under all load conditions:

Definitions of damage:

- 1) Damage is anticipated to be able to occur anywhere over the whole length of the raft between watertight transverse bulkheads.
- 2) Vertical extent of damage is anticipated to be equal to the depth of the raft calculated from the freeboard deck, but without this deck being regarded as damaged.
- 3) Transverse extent of damage is anticipated to be equal to 0.76 m measured inwards from the side of the raft perpendicularly on the centre plane at the level of the load line.
- 4) A watertight longitudinal bulkhead with a depth of 0.76 m or more from the side of the raft and which stretches between watertight transverse bulkheads and which has a depth of 0.76 m or more inside the side of the raft, shall be regarded as a watertight transverse bulkhead in relation to damage. The ends of the raft shall not be regarded as bulkheads.
- 5) If damage of a lesser extent than mentioned under paras. 2 and 3 results in a more critical condition, this damage shall be anticipated.
- 6) If pipes, channels or tunnels are placed in the anticipated damage area, the arrangement shall be such that it does not entail filling beyond that which is anticipated in the calculations in each damage event.
- 7) The following permeability figures are used:

– fittings for spaces and dry cargo	0,95
– empty spaces and tanks	0,95
– engine room	0,85
– stores	0,60.

10.3.4 Watertight integrity

A drawing shall be prepared showing the division into watertight sections.

Doors and routings in these bulkheads shall meet the requirements set out in NS 6082 and have sufficient watertight integrity documented. Openings in the freeboard deck towards underlying volume shall be of weather-tight design. Doors in to the stairwell shall have a threshold in accordance with the load line convention. Breather tubes from tanks which can cause pollution, shall have an approved automatic shut-off valve installed.

All ventilation of tanks, ventilation shafts and other openings which lead to rooms under the freeboard deck shall:

- have a minimum height over the freeboard deck of 760 mm;
- have opening heights above deck which with a 15-degree heel in a fully loaded condition does not come under water.

If openings to rooms under the freeboard deck have heights of between 760 mm and 2300 mm above the freeboard deck, a closing valve shall be installed.

Bulkheads shall be able to be fitted with flush hatches. These shall be marked and kept closed in high seas.

10.3.5 Loads from ice in the stability assessment

Calculations shall include unequal distribution of ice with the greatest load from ice both on the horizontal and vertical surfaces in relation to the ice class at the relevant site (see para. 5.5) on the one side and no ice on the other side. In calculations, ice shall be treated as accidental load.

10.3.6 Freeboard

The freeboard mid-ships shall be determined based on stability, trim and hull strength. This is the design waterline of the freeboard.

The following requirements apply to the freeboard, F_{\min} :

$$F_{\min} > 17 \times \text{LOA} + k_1 + k_2 \text{ [mm]}$$

where:

LOA is the raft's greatest length expressed in metres;

k_1 is determined by the wave height in accordance with Table 12;

k_2 is extra freeboard requirement at cross-mooring, set at $2000/B$ where B is the raft's greatest width in metres.

Table 12 – Freeboard requirements in relation to wave height

Dimensioning, significant wave height, H_s m	k_1 mm
$H_s < 0,5$	300
$0,5 \leq H_s < 1,0$	400
$1,0 \leq H_s < 2,0$	500
$2,0 \leq H_s < 3,0$	600
$H_s \geq 3,0$	700

10.3.7 Load line

Each longitudinal side of the raft will be appended a mark in the form of a white stripe, 400 mm long and 25 mm wide. The mark shall be placed so that the distance from the upper edge of the mark to the upper edge of the deck is at a minimum equivalent to the minimum requirement for freeboard. Further, under no circumstances shall the line be placed higher vertically than that the upper edge of the mark is lower than, or equal to, the dimensioning waterline indicated in the paragraph dealing with freeboard. The mark shall be well visible and not covered by fendering etc.

When the raft is in use, it is the user's responsibility always to ensure that the raft is not loaded higher than the load line.

10.3.8 Pump and hosing systems

It shall be documented that the raft is equipped with sufficient pumping capacity for each of the watertight sections. There shall be separate systems for pumping of watertight sections and hosing.

Pumping capacity should be ensured with at least two pumps, each with a capacity, Q , of:

$$Q = \varnothing^2 \cdot 5,75/1000$$

were

$$\varnothing = 1,68 \cdot \sqrt{L(B + D)} + 25$$

and

L is the length of the section (m);

B is the width of the section (m);

D is the depth of the section (m);

Q is the pumping capacity (m^3/h);

\varnothing is the pipe bore (mm).

Each watertight section shall have a permanent possibility for pumping. The requirement for pumping may nevertheless be waived if the number of watertight sections is so many that the risk of filling with water is negligible in relation to buoyancy and heeling.

10.3.9 Hull penetrations

Hull penetrations for pipes and hoses shall be watertight. It shall be documented that the feed hoses cannot function as water carrying hoses with the appurtenant danger of filling rooms and reduction of buoyancy. The safeguarding systems may also be documented in the user handbook. In addition, the feed hoses or other equipment shall not penetrate the hull lower than 400 mm under the freeboard deck.

10.4 Fire and safety

A safety plan shall be drawn up showing the placing of fire, rescue and safety equipment. A valve shall be installed on the fuel system which shall be able to be operated outside the engine room.

10.5 Production

10.5.1 Competence

All welders and installation technicians shall possess documented competence to perform the processes they actually perform. The same applies to inspectors and those performing tests, i.e. in the form of NDT. All welds on the hull shall be performed in accordance with approved procedures. Welders shall possess an approved certificate in accordance with NS-EN 287-1 and NS-EN ISO 9606-2. This also applies to welders performing repairs.

10.5.2 Inspection of steel rafts

NDT in the form of x-ray examinations of weld connections shall be undertaken in accordance with NS 470 and NS-EN 473.

10.6 Mooring and towing

As a main rule, a raft shall not be constructed so that it is moored directly on to the floating collar. Any connections between raft and floating collar shall be the weakest link. Rafts can be exempt from the first requirement if it can be shown through calculations that the floating collar with appurtenant mooring is dimensioned for mooring of rafts.

Mooring of the rafts shall take place on the basis that all mooring parameters with appurtenant specifications are given. This includes that the number and placing of the attachment points are given. The greatest strength and three-dimensional direction (or limit values for three-dimensional direction) for each attachment point shall be given. Material and planning of all attachment points shall be specified. .

NOTE The variations in the line characteristics of the various mooring lines can give large loads.

For towing, the following documentation shall be drawn up:

- attachment point for towing hawsers;
- maximum towing velocity and allowed wave and wind loads when under tow.

10.7 Requirement for documentation of planning and production:

The requirements for documentation are as follows:

- assembly drawing of the raft showing all relevant measurements;
- specification of functional requirements which shall be met;

NOTE For example, this can be if it is possible to drive a truck on the raft, or how large a boat can come alongside.

- description of the environmental loads it shall tolerate, at a minimum, wind, current, waves, temperature, ice and snow, particularly in relation to stability;
- description of the functional loads it is dimensioned for, particularly connected to direct operation, such as load from equipment, feed, personnel, etc.;
- description of the permanent loads on the raft, in the form of weight/buoyancy, and distribution of them;
- description of accidental loads, for example unequal load because of a break in the mooring line, no buoyancy in a watertight section, etc.;
- statement of limit states that are assumed, in the form of size, weight, maximum load, etc.
- greatest weight and distribution of ice;
- description of requirements for the mooring system;
- statement of the force of the mooring lines, i.e. maximum allowed force of mooring lines with regard to the whole raft and each part, as well as the largest allowed vertical force with regard to drawing down or heeling of the raft;
- design working life.

Each raft shall be equipped with a stability log, which at a minimum shall contain the following:

- the main dimensions and capacities of the raft;
- general arrangement;
- tank plan;
- watertight integrity plan;
- results of heeling tests, or results from heeling tests of a prototype with confirmation of accordance;
- any instructions regarding loading;
- calculation of ice load;
- intact stability, state 1 – 7;
- damage stability;
- hydrostatics;
- cross curves.

The stability log shall be available with drawings of the raft's overall dimensions, such as built, and with stability updated with the results of the heeling tests.

10.8 Marking of rafts

The equipment shall be marked with the following information:

- reference to this standard;
- maximum load;
- any drivable axle load (use of truck or similar);
- date of production;
- producer.

EXAMPLE NS 9415, maximum load 50 tonnes, drivable axle load 4 tonnes, 2003-03-17, Omvega A/S

Each raft shall be delivered with a rigidly mounted unique identification number.

Parts which are included shall be entered on to a parts list which ensures traceability.

11 Requirements for mooring

11.1 General

The requirements in this chapter assume that one also knows the requirements in the other chapters in this Standard.

11.2 Planning and production

11.2.1 General

A mooring shall keep the marine fish farm in the correct position and in a three-dimensional position. The mooring shall not affect the remainder of the marine fish farm in such a manner that it increases the danger of fish escaping. This means that the mooring shall be designed based on the site's environmental conditions and use, as well as the characteristics provided by the designer of the floating collar. The mooring shall be designed based on the information regarding additional loads from the net pen and any extra equipment, as well as information regarding how these will move during use and under all environmental circumstances that can occur.

The starting point for the requirements for mooring shall be the dimensioning values given in site surveys.

Loads from the mooring system on the floating collar shall be within the limitations given by the supplier of the floating collar.

11.2.2 Dimensioning of the mooring

The accidental limit state shall be set based on the following events: progressive breaks, drifting, capsize or sinking in the event of special loads such as collision with a boat, raft or extra equipment. Two aspects shall be checked:

- breaks in a mooring line: Conditions i para. 6.5.6.2 shall be calculated and documented. The material factor in Table 13 shall be divided by 1.5;
- spring tide: The marine fish farm shall tolerate a rise in water level of 1 meter in addition to current and waves. The material factor shall be divided by 1.5.

The requirements shall be regarded as met if the following types of error are documented with sufficient certainty:

- rise in water level: The water level rises to one metre above the upper tide water level (storm surge). Sufficient strength and flexibility shall be documented for the mooring lines and attachments for them. The effects of wind, waves and current shall be incorporated in the load combination;
- drifting: The conditions in para.6.5.6.2 shall be used as a basis. The planned strength in these conditions and their resistance to drifting as a result of further progressive breaks in mooring lines and the attachments for them shall be checked. The effects of wind, waves and currents shall be incorporated in the load combination.

The serviceability limit state shall be evaluated and documented based on the danger of reduced functional capability or reduced durability under normal conditions.

NOTE Examples of this are undesirable movements of the marine fish farm, local damage without further impact, and damage which affects the marine fish farm in relation to design working life.

11.2.3 Specifications for floating collar with net pen

The mooring shall be adjusted to the specifications from the producer of the floating collar.

11.2.4 Principles for planning and dimensioning

11.2.4.1 Characteristics

The mooring system shall be dimensioned to:

- tolerate all expected loads and deformations with satisfactory safeguarding against breaking;
- function satisfactorily based on the environmental conditions at the locality and use as well as the chosen floating collar with net pen and extra equipment;
- be sufficiently safeguarded against an unforeseen event developing into an accident of larger proportions than the causing event;
- possess sufficient durability against destructive effects of a mechanical, chemical, physical or biological nature (corrosion, rotting, crumbling away, photochemical oxidation etc.).

11.2.4.2 Arrangement and three-dimensional geometry

During planning of the mooring system, consideration shall be paid to both the character of the site and the specifications of the marine fish farm itself. The following requirements shall be met:

- the size and three-dimensional direction of the forces exercised by the mooring on the floating collar shall be in relation to the specifications set by the designer of the floating collar;
- the aim shall be to have the individual mooring line approximately the same length where this is possible based on the marine fish farm installation's placing and the (bottom) topography of the site;
- the mooring lines shall be laid so that they follow the bottom topography. This also means that they shall not be exposed to chafing against rocks, stones or other hard objects on the bottom;
- no chafing shall take place between different lines, and lines crossing one another shall be avoided as far as possible;
- the mooring lines shall be laid so that the mooring system shall not lead to chafing on the net pen or other main components, and documentation for this shall be provided.

11.3 Requirements for construction parts

11.3.1 Chains

The choice of chains shall take place based on requirements for strength in relation to the mooring calculation.

When chains are used for the bottom attachment, both stud link chain and studless chain can be used. Used chain can be used, but with a material factor in accordance with Table 13. Consideration shall be paid to a reduction in nominal diameter due to previous wear. This chain shall satisfy the requirements stated in ISO 1704, however, this requirement can be waived if it can be documented through the mooring analysis that it is appropriate. At a minimum the chain shall be delivered with Test Certificate 3.1 in accordance with NS-EN 10204.

In other parts of the mooring it will be appropriate to use lighter chain with a higher tensile strength. This shall be protected against corrosion, tempered, and maximum Class 7. The chain shall have an inward link length of maximum $6.58 \times \text{diameter}$.

All chains shall be load tested under production for welding and material faults. Corrosion protection shall consist of hot-dip galvanizing or methods giving equally good protection. Load testing shall be performed on all chains after corrosion protection, and the method of this shall be described. The chain and its components shall be tested in accordance with the requirements in NS-EN 1677-1, NS-EN 1677-2, NS-EN 1677-3 and NS-EN 1677-4. Load testing in the form of tensile testing shall be done up to 62.5 % of the breaking load on each part.

For information regarding hydrogen embrittlement and stress corrosion, see informative Annex 1.

The chain shall be delivered with a test certificate, at a minimum 3.1 in accordance with NS-EN 10204, which confirms compliance with the testing regime of the above-mentioned standards.

NOTE: By "test certificate in accordance with the NS-EN 1677 series" is meant the same as "the producer's self-declaration/producer certificate".

When laying out moorings, consideration shall be taken to the chain's characteristics, i.e. applied force and minimum diameter of the chain drum. Any requirements and limitations for laying out shall be specified by the chain supplier and included in the mooring user handbook.

11.3.2 Shackles

Shackles for use in the moorings shall meet the requirements stated in NS-EN 13889.

Shackles especially developed for fish farming can be used if they meet the general requirements for shackles that are mentioned above. The producer shall then be able to document accordance between breaking load / deformation load in accordance with para. 6.5 and Table 13 in this standard.

Shackle bolts shall be doubly secured.

NOTE 1 Double securing can be in the form of nuts and cotter pin.

The cotter pin shall be of a corrosion-resistant material / surface coated and must not contribute to increased corrosion of other parts of the shackle.

NOTE 2 The cotter pin can be made of plastic-covered and/or galvanised steel wire.

All shackles shall be documented with a traceable material certificate for bow and bolt. The minimum breaking load (MBL) of the shackle shall appear in the documentation.

For connection and splicing of the stud link chain, shackles which meet the requirements in ISO 1704 can be used. They shall be dimensioned as chain parts in accordance with Table 13.

11.3.3 Connecting elements

Connecting elements of different designs are allowed to be used. The condition is that sufficient strength can be documented for the area of use in the mooring system. This means evaluation of three-dimensional strength.

Lifting lugs at the connecting point shall be dimensioned as lifting equipment in accordance with NS-EN 1677. Consideration shall be paid to pre-tension when the connecting point is lifted. Connecting points (coupling discs) of steel shall be dimensioned so that the first yield will always occur in one of the attachment points for the mooring lines and never in the plate itself.

Capacity shall be calculated in all possible break sections, and yield stress shall be regarded as capacity criterion. Flow capacity shall not be higher than 270 MPa. A material factor of 1.5 shall be used. It shall be stated whether probable crack sections are found which result in fractures, such that several mooring lines loosen from the connecting point.

For coupling elements of rope, a safety factor shall be used as for regular knots. Chafing shall be especially assessed for the specific solutions. In addition, outgoing ropes shall be clearly marked with codes so that the placing of the respective ends in the system is stated. For such connections, all possible breaks having a capacity of less than 1.8 times the break surface with minimum break capacity shall be anticipated as accidental load (see para. 6.5.6.2).

11.3.4 Fibre rope

3-strand rope and/or hawsers (braided) of various fibres shall be used for moorings where there is a requirement for fibre ropes. They shall meet the requirements in NS-EN ISO 1346, NS-EN ISO 1140 and NS-EN ISO 1141 for polypropylene (PP), nylon (PA) and polyester respectively. Other types of fibre rope can be used, provided that they satisfy the requirements which can be derived from the mooring analysis. All fibre ropes shall be accompanied by a test certificate certifying compliance with the above-mentioned standards.

Synthetic rope shall not be laid over sharp edges which can cause wear and chafing when the rope is under load. When using knots, consideration shall be paid to the weakness in the rope that the knot represents.

NOTE A synthetic rope is greatly weakened in areas with knots, with a strength reduction of approximately 50%. There must be a curvature diameter of approximately three times the rope diameter in order for the rope not to be weakened considerably.

11.3.5 Buoys

Only buoys that are dimensioned to tolerate submersion with the greatest load on the moorings lines shall be used. The minimum breaking strength shall be stated. The buoy and attachment shall tolerate external forces from: waves, current, icing, drift ice, flotsam and boats. Connection to the buoy shall be dimensioned as lifting equipment in NS-EN 1677. Steel details shall be sufficiently protected against corrosion to be able to prevent corroding throughout the buoy's dimensioned useful life.

11.3.6 Bottom anchor points

11.3.6.1 General

Dimensioning of bottom anchor points shall be based on thorough charting of the bottom conditions at the site, see para. 5.6. All bottom anchor points shall be suited to the site's depth, topography and type of bottom, including assessment and documentation of the holding power of the bottom substrate. The holding power of the bottom shall be assessed and documented both as regards ultimate limit states and accidental load limit state.

11.3.6.2 Anchors

Dimensioning of anchors shall be undertaken with regard to the geological conditions at the site and/or on the basis of the results of test loads. It shall be established that the holding power of the bottom is sufficient in relation to the mooring analysis. The holding power of the anchor shall exceed the dimensioning force in the mooring line in order to take into consideration that the anchor is exposed to constant stretching combined with cyclical load.

11.3.6.3 Rock bolts

Rock bolts shall be tempered and protected against corrosion.

All rock bolts shall be documented with a traceable material certificate, at a minimum 3.1 in accordance with NS-EN 10204. The minimum breaking load (MBL) of the rock bolts shall be stated on the documentation.

Installation procedure shall be available and be followed.

The producer shall be able to document consistency between the smallest breaking load / deformation load in accordance with Table 4 and Table 13 in this Standard. The producer shall then be able to document consistency with the minimum breaking load / deformation load.

11.3.6.4 Dead weight moorings

By the use of dead weight moorings, the slide resistance and resistance to rising as well as the combinations of them shall be calculated. It shall be substantiated that the holding power of the dead weight mooring is at least twice the dimensioning force in the mooring.

11.3.7 Attachment points to floating collar

The holding power of all attachment points shall be documented. This shall be done either by empirical data from the supplier or carrying out tests.

11.4 Materials

The materials shall be in accordance with the documentation from the supplier. The producers shall have documentation which states producer, trade name, material type, characteristics and marking of the product. The characteristics shall derive from the result of tests carried out in accordance with documented methods. Relevant characteristics shall be documented. For steel, the following shall be included in the documentation at a minimum:

- maximum and minimum hardness and strength;
- impact resistance at LAST (Lowest Ambient Surface Temperature);
- ambient temperature;
- chemical composition of the steel.

The documentation shall be included in a material certificate.

The material factor shall be used in accordance with Table 13.

Tabell 13 – Material factors for mooringlines

Type	Material factor
Synthetic rope	3,0
Synthetic rope with knots	5,0
Chains and chain components	2,0
Used chains	5,0
Coupling discs and other connecting points of steel*	1.5
Shackles	2,0
Rock bolts and other bottom attachments	3,0
*First yield	

For parts where the material factor is not stated in Table 13, the producer shall state the product's material factor. This shall be documented.

Material factors for parts are based on installation and use in accordance with the supplier's instructions for use. In the event of load angle not included in the description in the user instructions, the material factor shall be adjusted in co-operation with the producer. Coupling discs are calculated in relation to the first yield.

11.5 Corrosion

Regarding mooring parts of steel that are not inspected annually, the thickness shall be expected to decrease by 0.4 mm per year between each inspection.

11.6 Fatigue

11.6.1 General

Fatigue is dependent on load variations over time. Consideration shall be paid to loads which vary with wave frequency.

11.6.2 Fatigue in chains of steel

A fatigue analysis shall be carried out for chains of steel. Fatigue of chains shall be calculated in accordance with SN curve methodology, with the number of cycles to break, n (s):

$$\log(N(s)) = \log(a) - m \cdot \log(s)$$

It shall be expected that no fatigue limit and m -value shall be 3.0. The following a -values shall be used:

$$\text{Studless chain: } a = 6 \cdot 10^{10}$$

$$\text{Stud link chain: } a = 1,2 \cdot 10^{11}$$

A starting point of 20 years design working life shall be used.

NOTE Lifetime for stud link chain is strongly dependent on how well the stud is fixed. It is therefore recommended that studless chain be used.

For more information, see Annex, DNV OS-E301.

11.6.3 Fatigue in synthetic rope

If requirements for the tension level for ordinary polypropylene rope are met (up to 170 MPa), the rope is regarded as having sufficient fatigue capacity if all other requirements regarding material, design working life and inspection are satisfied. If rope with a higher breaking stress than this is used, an equivalent fatigue capacity shall be documented through testing.

11.7 Swing mooring

It shall be documented that the mooring system for a swing mooring has a redundancy which gives at least the same security as the mooring system for marine fish farms designed on the background of this Standard. Further, it shall be documented that the mooring can be placed in a site under the conditions that are described in the site survey.

11.8 Mooring of rafts

As a main rule, a raft shall not be designed so that it is moored directly to the floating collar. Any connection between the raft and floating collar shall in that case be the weakest link. Rafts can be excepted from the first-mentioned requirement if it can be proved by calculations that the floating collar with appurtenant mooring is dimensioned for mooring of rafts.

Mooring of rafts shall take place on the basis that all mooring parameters with appurtenant specifications are given. This includes that the number and placing of attachment points are given. The largest force and three-dimensional direction (or limit states for three-dimensional direction) for each attachment point shall also be stated. Material and planning of all attachment points shall be specified.

NOTE The variations in the line characteristics of the different mooring lines can put great loads on the raft.

Mooring of rafts shall be calculated and dimensioned according to the same rules as for floating collars with net pens and extra equipment.

Mooring of rafts shall not be designed so that it can cause damage to the mooring of the marine fish farm itself, floating collar or net pen. This shall be documented.

In placing the raft in relation to the rest of the marine fish farm, consideration shall be paid to the prevailing direction of wind, waves and current, as well as the danger of icing. Rafts shall preferably be laid out on the leeward side of the marine fish farm.

11.9 Requirements for laying out and after-inspection

Laying out shall take place in accordance with a laying out plan. After the mooring is laid out, the requirements in the mooring calculations shall be controlled for compliance. In the case of significant deviation in positions and depths in relation to the calculations which have been used as the basis for the laying out plan, it shall be verified that the change has not led to significant weakening of the mooring.

Layout out of moorings shall take place so that none of the mooring elements are damaged during the laying out process.

NOTE Chain can be damaged by the pulley/wheel/drum that the chain moves over having a diameter that is too small, that too few (there shall be at least four) chain links have a contact surface against the wheel/pulley, or that it is exposed to great a load during the laying out phase from self-weight combined with the weight of sinkers and bottom attachments. The latter can be avoided by the bottom attachments being sunk by the use of a crane which via wires is fixed to the uphaul of the bottom attachment.

After laying out a visual control shall be performed to ensure that the result of laying out has taken place in accordance with the laying out plan. Before fish are set out in the marine fish farm, it shall be established by tests and/or after-inspection of the whole of the mooring, including anchors and rock bolts, that the mooring has the characteristics required by the mooring analysis, including holding power of the bottom attachments.

Further inspection and/or testing shall take place according to a fixed plan which includes time intervals for inspection and testing, based on risk analysis. This shall also include listing of events which shall result in any increased after-inspection and testing, as well as the plan for (periodic) replacement of parts.

11.10 Requirement for documentation

A sketch showing measurements of the mooring at the site shall be available. The producer or supplier of the mooring system shall document that the system is suitable for the site. This shall be supported by calculations and dimensioning. There shall be a documented analysis of the relevant mooring system available at all sites.

A specification shall also be available of each anchor or bottom attachment. At a minimum this shall include a product statement (concrete weight, drag anchor, rock bolt, etc.) as well as mass and weight and/or expected holding power.

A specification of each shore attachment shall be available. At a minimum this shall include dimensions of the bolt, attachment method, corrosion protection, ground conditions and other relevant data.

A documented assessment shall be available of the impact of accidental loads such as unequal loads because of a break in the mooring line, loss of floater, dragging of anchors and similar occurrences.

Documentation of the mooring system shall give a description which is good enough to be able to assess/recalculate the moorings. Requirements for documentation of the mooring system's planning:

- specification of each mooring line, at a minimum an overview of building up in segments with bottom attachment/shore attachment, line type, grommets, shackles and other extra equipment. The mooring line's diameter, breaking strength, buoy, deadweight with weight, volume and placing and material data such as elasticity and weight per unit of length shall be stated where relevant;
- fundamental assembly drawing of the marine fish farm with laying patterns, attachment points, indication of line lengths and length/depths of depth-dependent line lengths;
- expected limit states in the form of functional requirements which shall be met, i.e. whether the gangway shall be connected, or whether the wellboat shall be able to come alongside the marine fish farm;
- assumed limit conditions in the form of what loads the mooring system can tolerate, including which maximum mooring line stretch can be expected as a result of static and dynamic movements in the terminal point. Loss of a random mooring line shall not entail progressive breaks in the mooring system or resulting damage to the floating collar / net pen;
- all certificates and declarations which confirm the compliance of parts with Standards and other specifications and requirement documents;
- stated design working life on all parts.

Annex A (informative)

Background information for site survey

A.1 Introduction

The Annex provides background information for the description of the marine fish farm's exposure to waves, current and wind.

A.2 Site classification

The tables in this paragraph are used for conversion of site classes determined by the use of the first edition of the Standard and to describe the greatest exposure to wave and current in this edition of the Standard.

Table A.1 – Wave classes at the site decided by dimensioning, significant wave height and wave period (in accordance with the 1st Edition of NS 9415)

Wave classes	H _s m	T _p S	Designation
A	0,0 – 0,5	0,0 – 2,0	Little exposure
B	0,5 – 1,0	1,6 – 3,2	Moderate exposure
C	1,0 – 2,0	2,5 – 5,1	Substantial exposure
D	2,0 – 3,0	4,0 – 6,7	High exposure
E	> 3,0	5,3 – 18,0	Extreme exposure

Table A.2 – Classification of site based on midcurrent (in accordance with the 1st Edition of NS 9415)

Current classes	V _c m/s	Designation
a	0,0 – 0,3	Little exposure
b	0,3 – 0,5	Moderate exposure
c	0,5 – 1,0	Substantial exposure
d	1,0 – 1,5	High exposure
e	> 1,5	Extreme exposure

A.3 Description of parameters

A.3.1 Wind

A.3.1.1 Wind in the coastal zone

Expected extreme wind is almost the same along the coast from Lindesnes to Nordkapp (NS-EN 1991-1-4). Typically, the one-year wind lies around 28 m/s and the 50-year wind around 35 m/s along the outer coast. The wind drops off inland from the coast. This is due to the fact that the wind is reduced as a result of friction over land. A wind of 10 km – 20 km in from the coast can be 20 % – 30 % lower than the wind outermost in the skerries. After this the 50-year wind in the coastal zone typically varies between 25 m/s and 35 m/s. Generally, the onshore wind will be considerably stronger than the offshore wind.

Since the wind varies relatively little along the coast, there is little point in describing the site according to the wind climate.

Norsk Standard NS-EN 1991-1-4 indicates the 50-year wind for areas with scattered small buildings and trees (Terrain Category II) as reference velocity. For areas near the coast without trees and bushes (Terrain Category I) the wind is 17 % higher.

A.3.2 Waves

A.3.2.1 Swells

Ocean swells are waves which push in from the sea. A fish farm will usually be located in an area which is relatively well protected from direct wave occurrence from ocean swells, behind islets and skerries. The wave height for incoming ocean swells will therefore be significantly lower than for the sea outside. The wave period, however, will be almost unchanged. Incoming ocean swells (high waves) will typically have peak periods in intervals of 10 s – 18 s, increasing with the increasing wave height.

A.3.2.2 Locally generated wind sea

Locally generated wind sea is set up in the sea area around the fish farm. This sea is completely determined by wind velocity, duration of the wind and the effective fetch length. The fetch length is the distance from the fish farm to the nearest land calculated in the wind direction. The effective fetch length depends on the width of the fetch. In the case of narrow fjord arms, the effective fetch length can be significantly less than that measured.

It can be expected that the wave height increases (almost) proportionately with the wind velocity and proportionately with the square root of the fetch length. Examples of the connection between waves, wind and fetch length are given in Table A.3. It will be seen from the table that the peak period for locally generated wind sea is typically 2 s – 7 s, that is to say significantly lower than for ocean swells.

Table A.3 – Examples of calculated significant wave period and peak period in varying wind velocities and fetch length

Wind velocity	Effective fetch length					
	3 km		10 km		30 km	
	Significant wave height m	Peak period s	Significant wave height m	Peak period s	Significant wave height m	Peak period s
10	0,3	2,1	0,6	3,1	1,1	4,4
20	0,8	2,8	1,5	4,1	2,5	4,9
30	1,4	3,3	2,5	4,9	4,4	7,1

A.3.2.3 Description with regard to wave exposure

There is a great difference in the peak period for ocean swells and locally generated wind sea. This is significant for the response of various marine fish farms to wave occurrence. It seems, therefore, appropriate to differentiate between areas stated in type of sea:

- areas (H) where ocean swells prevail;
- areas (V) where wind sea prevails.

In addition to the type of sea state, one must differentiate between the degree of exposure to wave occurrence. A description is most effectively achieved by stating dimensioning, significant wave height.

A.3.2.4 Determining wave height

The wave height at the place of location of the fish farm can be determined in several ways, i.e. based on information from local area experts upon on-site inspection, calculations based on wind data, calculations based on information about incoming ocean swells, or based on measurements.

A.3.2.4.1 On-site inspection

It will often be possible to arrive at a relatively good description after an on-site inspection of the relevant fish farming location. Local area experts will as a rule be able to give an estimate of the largest waves occurring in the area during the year. This estimate can be assumed to be equivalent to the one-year significant wave height. The 50-year significant wave height for wind sea is approximately 25 % higher. Upon inspection, information will also be obtained regarding the wave height by studying how high the waves break along shore, the height of the vegetation above water level, how high driftwood, seaweed etc. is washed up along the beach, whether the waves break over quays, etc.

A.3.2.4.2 Calculation based on wind data

When the fish farming site is protected against incoming ocean swells, the wave height can as a rule be calculated based on wind data. This assumes that the long-range wind statistics from a nearby weather station are available. Significant wave height is determined based on the wind velocity and fetch length, that is to say that the free sea area over which the wind blows calculated in the wind direction. The 50-year wave is equivalent to the wave calculated based on the 50-year wind.

A.3.2.4.3 Calculations based on incoming ocean swells

When the fish farm is mainly exposed to incoming ocean swells, the wave height will be able to be calculated based on information (long-range statistics) about the wave height on the sea. This assumes that the open sea outside the fish farm installation is fairly clean, i.e. there are few underwater rocks and skerries over which the waves break. If the open sea outside is not clean, the uncertainty of such calculations will often be too great.

A.3.3 Currents

A.3.3.1 Wind-induced currents

When the wind blows over the sea, parts of the wind energy are transferred to the surface of the sea, and a wind-induced current is set up at the same time as the wind contributes to mixing the water masses. If the sea is almost homogenous (i.e. the density is about the same in the depths), larger parts of the wind energy are used for mixing and less for inducing wind currents. If there is a strong layer division in the water, which there often is in Norwegian fjords with rivers discharging, the thermocline between the layer of brackish water, and the fjord water underneath acts as an energy blockage. The wind energy will then be absorbed in the upper layer of brackish water, and the largest part of it will be used to induce current while lesser amounts will be used for mixing.

The rule of thumb that the wind-induced current on the surface is 2 % of the wind velocity is often applied. A continual storm of 25 m/s should then induce a wind current of 50 cm/s. In fjords and other layered water masses the wind-induced current is often stronger than in the open sea, especially if the wind blows over a larger area (long fetch length). Continual, strong wind that blows out over a long and fairly straight

fjord, will be able to induce a significant wind-induced current. Wind in the opposite direction (in to the fjord) will not have the same effect. On the contrary, it will pile up the water up the fjord. When the wind changes direction or drops, this piling will "drop", and a strong, but short-range current directed outwards will be induced. This is called "wind-piling current". Typical duration is a couple of hours, and the velocity can be 70-80 cm/s.

The wind-induced current is strongest at the surface and reduced with depth. In strongly layered water the thermocline will form the boundary for how deep the wind energy can be noticed. In open sea the lower boundary is about 50 m in our waters.

A.3.3.2 Tidal current

The tidal current is induced by the periodic wave movement of tidal waters. It is permanent, changing and predictable.

In open sea the tidal current will be in phase with the tidal wave. Tidal currents are weakest off Jæren. There the 100-year tidal current is calculated at approx. 20 cm/s. The velocity increases southwards and northwards. Off Bodø it is anticipated to be 30 cm/s, while it is up in 40 cm/s – 50 cm/s off the coast of Nord-Troms and Finnmark.

In fjords, the tidal wave will contribute to increase and decrease the water level in the fjord area inside. Here the tidal current is zero at high water and low water, and strongest in the middle. With knowledge of the surface area of the fjord and the height of the tide water, the tidal current can be calculated in every point where the cross-sectional area is known. Large fjord area, high tide and narrow inlets give strong tidal currents (cf. Saltstraumen).

A special tidal water phenomena often occurs in sounds. If the tidal wave travels outside the sound, a water level difference occurs on each side of the sound. This difference is attempted equalised by water flowing from the area with a high water level to the area with a low water level. This tidal current can be very strong, and such sounds are often called tidal sounds (jf. Rystraumen in Troms and Kvalsundet in Finnmark, both with velocities up to 2 m/s – 2,5 m/s).

Tidal currents are relatively constant with depth. Near the bottom, however, it will meet the friction and reduce in strength.

A.3.3.3 Pressure-driven current, including break-out from the coastal current

Density differences will be attempted equalised by inducing current. The same happens when the water level is different. A river discharging to a fjord causes an outward-directed brackish water current in the surface layer. The coastal current along the Norwegian coast is another example of pressure-driven current.

While the pure tidal current and (partly) the wind-induced current are determining in the sense that the velocity can be estimated for a given site, the pressure-driven currents are more complex and difficult to predict. It is known that the coastal current flows northwards along the Norwegian coast with velocities in the region of 50 cm/s. With low pressure areas over the North Sea, a south-westerly wind often starts in Skagerrak. This wind decelerates the coastal current, and an extensive wind-piling occurs. When the wind-piling drops, there is an outbreak in the coastal current. The velocity can get up to over 1 m/s, and the current can be spread in to the fjord arms, especially on the West coast, as a relatively strong intermediate in-flowing.

The topography in an area here will be of great importance. When a given volume of water flows northwards along the coast, between rocks and skerries or inwards in the fjords and meets obstacles in the form of shallow parts or narrow sounds, the velocity of the current based on a continuity view must increase so that the same volume shall be able to get through. This is in contrast to the tidal sounds where the water level difference on each side of the sound determines the velocity of the current.

The pressure-driven current, like the tidal current, is relatively depth-constant. The velocity of these currents and how often they occur, can often only be determined by direct current measurements.

A.3.3.4 Spring flood

Spring flood in connection with snow and ice melting in many cases will contribute greatly to the velocity of the current. Typically this takes place during the months April to June. This effect can at times be so great that it dominates everything else. If the site indicates that a strong current can be expected in connection with ice and snow melting, an assessment should be made as to whether current measurements should be taken during this period.

A.3.3.5 Description with regard to current exposure

The response of various marine fish farms to current exposure does not differentiate between which driving force is the cause of the current. To some degree, duration and frequency can play a role, but it is mainly the velocity and direction of the current in relation to the marine fish farm that is decisive.

A.4 Directions

The direction of the current as a rule defines the prevailing direction for the marine fish farm. The most unfavourable direction or the direction which gives the greatest load shall be used if the marine fish farm is moored so that it follows the current (weathervane effect).

Wind and wind-driven waves shall be assumed to be concurrent and most unfavourable in relation to the direction of the current. Swell shall be assumed to be the most unfavourable in relation to the marine fish farm's dimensions, that is to say in the longitudinal direction to the marine fish farm. If possible, wind sea and swell shall be combined.

Annex B (informative)

Personal safety

A fish farm shall be arranged so that the working environment is completely safe regarding the employees' safety, health and welfare. Technical devices shall be inspected, assessed and documented in relation to environmental considerations.

In order to meet this requirement in an appropriate manner for exposed equipment such as feed rafts and feed stations, it shall be required that the producer provide documented calculations of strength, buoyancy and stability under all operational conditions.

Workplaces and working environments at feed stations and feed rafts, as well as working environments on shore, shall be assessed and documented in relation to the following points:

- light, climate, ventilation and noise;
- access;
- floor area and room height;
- daylight and view;
- ladders;
- railings;
- floor – anti-skid etc;
- escape routes;
- personnel rooms such as cloakroom, toilet and break room;
- outside workplaces;
- rooms for any board and lodging.

There shall always be a boat or rescue raft in place at the feed raft when there are people on board. If anyone stays overnight on board, the feed raft shall be equipped with an alarm system which gives warning in the event of water penetration or breakdown.

Workplaces on the floating collar and raft as well as access to them shall be dimensioned and fitted based on the activity which is to be carried out. The necessary precautions shall be taken in order to prevent danger of personnel injury by falls or falling objects.

Relevant technical devices and equipment shall be designed and equipped with safety devices so that persons are protected against hazards to life and health. This shall be based on charting as well as a risk analysis of work operations carried out on cages and rafts. The necessary safety measures on the background of this shall be documented.

Amongst other things, this means measures which ensure that the marine fish farm possesses sufficient strength, buoyancy and stability. The marine fish farm shall tolerate necessary loads from wind and waves, as well as from relevant equipment such as cranes, trucks etc.

Before technical equipment is installed and taken into use, the marine fish farm with appurtenant equipment shall be inspected thoroughly to ensure that the above-mentioned requirements are met. After inspection has been performed, documentation shall be available showing that the marine fish farm sufficient buoyancy, strength and stability.

Relevant safety devices shall be installed to prevent falls and driving into the sea. At a minimum this includes railings, anti-skid protection of all gangways, driveways and working platforms, skirting boards etc. as well as longitudinal safety edges on all driveways. The inner edge of the gangway shall have a skirting board of between 3 cm and 8 cm. The outer edge of the gangway should be equipped with the same type of skirting board. All driveways shall have a safety curb installed along the sides. These shall be 30 cm high. The side along the net pen shall be equipped with a railing consisting of hand and knee skirting board, installed at 1.0 m and 0.5 m respectively over the deck. Rope shall not be used as a material for a handrail.

NOTE Gratings are often appropriate for walking and driving on. They give good protection against sliding and other accidents.

Relevant safety devices/aids shall be in place to ensure that persons who have fallen into the sea can manage to get back on land or on board the marine fish farm.

At a minimum there shall be an easily accessible life jacket in summer as well as a survival suit in the winter. On gangways etc. where one cannot reach up to the edge from sea level, a ladder or similar means of access shall be installed. It shall reach at least 50 cm down into the sea. The distance between such ladders shall not be more than 20 m, or one ladder for each cage in the marine fish farm. Gangways and working platforms which float more than 50 cm above sea level, should be equipped with life ropes, installed in bays along the outside of the floating collar.

Lifebuoys with line and rescue hook shall be placed on the outside of the marine fish farm and on the gangway. The distance between each lifebuoy shall not be over 50 m.

The marine fish farm shall be well arranged ergonomically, amongst other things by a design which ensures appropriate work positions, as well as having sufficient width on walkways etc. The width of walkways shall be at least 90 cm, and the width around the cages shall be at least 60 cm.

In all relevant places the marine fish farm shall be equipped with appropriate and good lighting. Workplaces shall have lighting with a luminous intensity of at least 20 lux. Gangways, loading/unloading places etc. shall be equipped with lighting with a luminous intensity of 100 lux.

Procedures and safety measures for personnel working alone shall be in place. Working alone on marine fish farms should be avoided. If working alone nevertheless must be performed, there must always be an agreement with another person for regular contact and preparedness if an accident should occur. In winter a survival suit shall be used. In summer, at a minimum, a life jacket shall be used. In addition to a life jacket and survival suit, an alarm system shall be available. Written instructions shall be drawn up regarding working alone, if such is performed.

The producer shall supply user guidance in easily understood written Norwegian regarding set-up, operation and maintenance. User guidance shall be stored in an easily accessible place.

All chemical substances, i.e. medicines, disinfectants and proofing compounds, shall be transported and stored properly and used in accordance with the user instructions. All necessary safety equipment for handling of chemicals shall be available and shall be used. Everyone working with hazardous or flammable substances shall have the appurtenant occupational hygiene product data sheet available.

All marine fish farms shall be equipped with first aid equipment.

When working on a quay and with other harbour work which is done in an area immediately adjacent to the marine fish farm installation, such as work with loading, unloading, mooring etc., requirements shall be made regarding the following:

- equipment on the quay such as ladders, mooring points, fendering on the quay front, and lighting;
- rescue equipment such as lifebuoy with lifeline, rescue hook and rescue ladders;
- first aid equipment;
- fire extinguishing equipment;

Each raft shall have a safety plan posted on board in at least A-4 format. A copy of the safety plan shall be placed in a watertight cylindrical container in a suitable place. The drawing shall show the placing and number of.

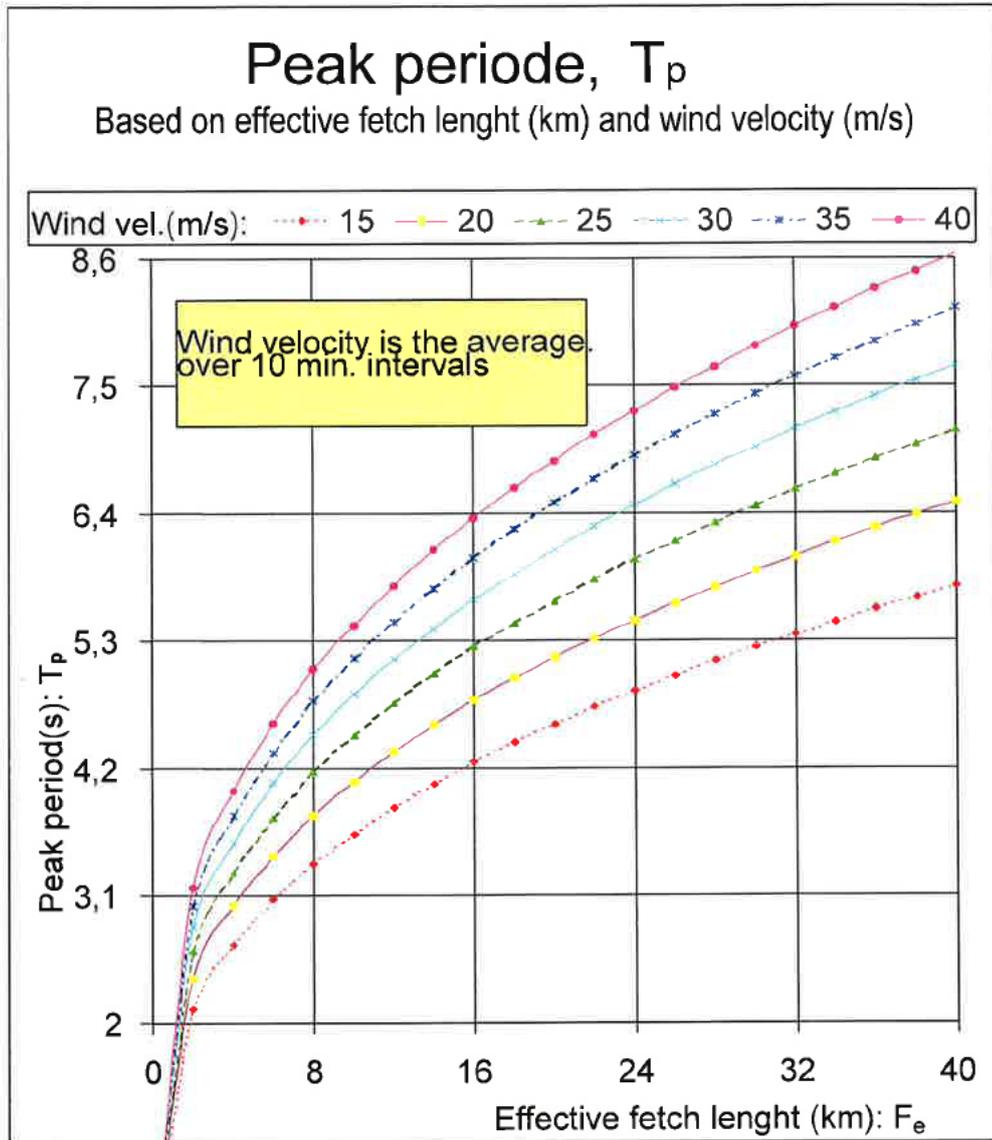
- fire alarm bells;
- switch for shutting down fuel supply;
- emergency stop switches for fuel pumps and any engine room fans;
- emergency stop switches for ventilation and fittings;
- sensors for smoke and heat detection;
- pumping equipment;
- level alarm;
- separate pumping and hosing systems;
- powder, water and CO₂ apparatus;

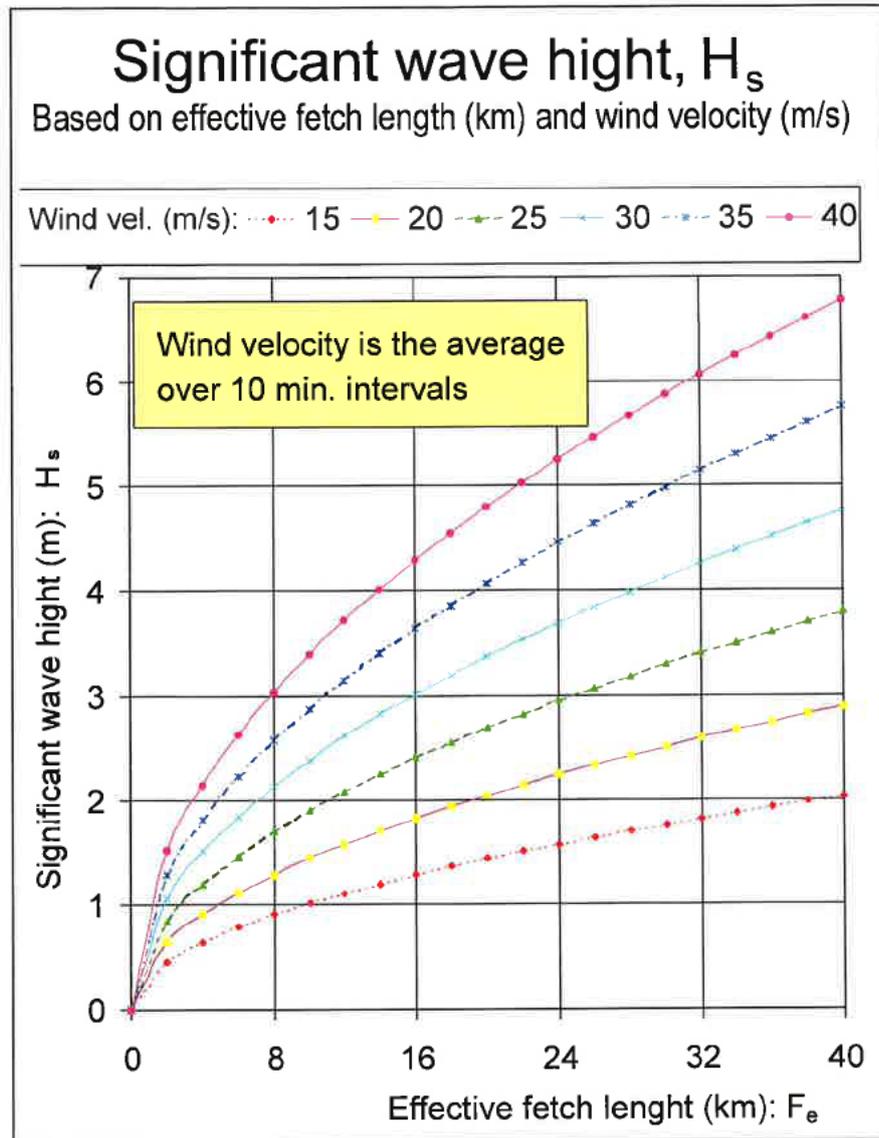
- fire axe;
- lifebuoys;
- life jackets;
- emergency lighting;
- first aid equipment;
- shutting down of ventilation valve;

Symbols shall be used for the equipment in accordance with the IMO Standard.

Annex C (normative)

Peak period based on effective fetch length, and dimensioning, significant wave height based on effective fetch length and wind velocity





Annex D (informative)

Dimensioning of floating collar in relation to extra equipment

The loads imposed on the main components of a marine fish farm by extra equipment being fitting on it, shall be documented. The impact in the form of damage/breakdown shall be explained.

Extra equipment is divided into three categories:

Fitted extra equipment: this consists of system units which are intended to be permanently mounted on a main component, or which are an integral part of the main component:

NOTE 1 Examples of fitted equipment are winch, dead fish/feed collector in net pen, artificial lighting, generator, battery, light filter, protective net and feed spreader.

– detached extra equipment:

NOTE 2 Examples of detached extra equipment are feed store and service station.

– separate or connected extra equipment.

NOTE 3 Examples of separate or connected extra equipment are gangway, feed station with hose connection and floating feed dispenser.

Regarding fitted extra equipment which is fixed to or placed in direct connection with a floating collar, net pen or a mooring system, an assessment shall be made and documentation provided for mutual static and dynamic effects between the extra equipment and the movements of the relevant equipment. Possible accidental loads and impact of accidental loads shall be specified and evaluated.

Regarding detached and separate/connected extra equipment which is not directly connected to the floating collar or the other main components, an explanation shall be available with all necessary calculations of the impacts loads and accidental loads from extra equipment will have on the floating collar, net pen and/or mooring system.

Documentation of extra equipment shall give a description which is good enough to facilitate assessment/supplementary calculation of the effects on the floating collar, net pen and mooring system. Requirements for documentation of the planning of extra equipment:

- specification of category placing. For new or significantly modified systems, a new assessment and documentation of category placing shall be performed;
- fundamental assembly sketch with all relevant measurements drawn in;
- specification of extra equipment with regard to functional requirements and mode of operation;
- specification of extra equipment with regard to capacity.

Contact should be established between designer/supplier of extra equipment, and the same for the main components that are affected. Extra equipment should be accompanied by a document recommending that it can be used together with the relevant main system. Any limitation in the use or fitting of extra equipment together with the relevant main system shall be clearly defined.

The different categories of extra equipment shall be accompanied by partly different types of documentation:

- Fitted extra equipment shall have an assembly and fitting drawing with suggested placing on the relevant type of installation, as well as a document which describes the loads the system imposes on the marine fish farm installation or parts of it, including mass, volume, area, drag and drag area.
- Detached extra equipment shall carry documentation showing the assessment by the classification institution, labour inspection authorities etc., where this is relevant.
- Separate/connected marine fish farms shall carry documentation showing the assessment by the classification institution, labour inspection authorities etc., where this is relevant. It shall also be accompanied by a document describing the loads the system, including attachment and mooring shall tolerate, including environmental loads from wind, current, waves, ice, snow and temperature, functional loads such as variable loads connected to the operation of the system, including equipment, load distribution and personnel, permanent loads, i.e. own mass and buoyancy and distribution of them, and accidental loads which are caused by breaks in the mooring lines or loss of buoyancy or load shift. A document shall describe which loads the system imposes on the marine fish farm or parts of it, including forces between the system and the marine fish farm as a result of own and the marine fish farm's terminal points' static and dynamic

movements. A document shall describe the limit states that are assumed, including attachment of the system to the floating collar, the mooring system of the marine fish farm and net pen, and including the attachment of the system with its own primary mooring.

It is a requirement that drawings, calculations and performance are reviewed, and that extra equipment is assessed and documented for use within the specified limitations of a named responsible person in the company or by an expert from an external company who can document satisfactory competence to be able to undertake such documented assessment.

Annex E (normative)

Strength of net pen cage in dimension class 0 in accordance with Table 11

In the case of documentation of the strength of a net pen which does not fall under the requirements in Table 2, the following should be specified:

- Which loads in the form of environmental loads the net pen is dimensioned to tolerate. At a minimum there shall be data for forces which are transferred by wave movements from the floating collar to the net pen, current forces on the net pen, and icing of the jump catch net ;
- Specification of which loads in the form of variable functional loads the net pen is dimensioned to tolerate. At a minimum, data shall be available for forces which are imposed by the use of a stretching system, from dead fish and from fouling;
- Specification of limit states which are assumed to be connected to the method of attachment of the net pen to the floating collar;
- Possible procedures for documentation of strength of a net pen which does not fit into the dimension class;
- Specification of limit states connected to size, weight, movements of the floating collar and forces imposed by handling of the net pen.

For submerged net pens, deformation and distribution of forces in the net pen from the following loads shall be calculated:

- Own loads, F_e , which is the net pen placed in a frame and with stretching system attached. A load factor of 1.25 shall be used.
 $L_1 = 1.25 F_e$.
- Loads from fouling, F_b shall be calculated.

NOTE 1 For example, mussel attacks which entail both increased weight of the net pen as well as reduced flow of water.

- Deformation of and forces on the net pen from these loads shall then be calculated with a load factor of 1.25. The following cases of load shall be checked both for deformation and forces:
 $L_2 = 1.25 (F_b + F_e)$
- Calculation shall be made of the response effect from loads due to effects on the net pen from the maximum current the net pen can be exposed to, F_s . For this load instance a calculation shall also be made of volume change. Particular attention shall be paid to velocity reduction (shadow effect) in the control of this load instance. This is particularly important for cages since the rear edge in relation to the current direction is in shadow in relation to the forward edge, because it gives less volume. The following load instances shall be controlled for the cage having the least shadow effect in the forward edge, and for the cage having the greatest difference between shadow effect in the forward and rear edges respectively. The forces on the net pen because of current, F_s , is non-linear in relation to current velocity, V_s , and the net pen's deformation. Deformation and forces shall be calculated for the following types of load:
 $L_{3a} = 1.2 (F_s + F_e)$
 $L_{3b} = 1.1 (F_s + F_e + F_b)$
- For non-circular cross sections, this calculation shall be performed for current velocity in relevant directions in relation to the net pen and must be assessed and documented in relation to global shadowing;
- Response due to waves shall be calculated. Waves shall be combined with current, fouling and own weight;

NOTE 2 Waves affect both the movement of the floating collar and the net pen directly.

- The net pen shall be calculated regarding relevant dimensioning waves, $W_{(H,T)}$ or sea states where H is the wave height and T is the wave period. The net pen shall be examined for the wave giving the greatest forces and deformation in the net pen. The following load combinations shall be examined:
 $L_{4a} = 1.2 (F_w + 0.8 F_s + 1.0 F_e.)$
 $L_{4b} = 1.1 (F_w + 0.7 F_s + F_e + 0.7 F_b)$
- Forces on the net pen which are imposed by handling shall be calculated. It shall be documented that the net pen will not be destroyed or impaired by imposition of forces by handling, F_h .
- $L_{5a} = F_h + 1.0 F_e.$
 $L_{5b} = F_h + 1.0 F_e. + 1.0 F_b.$
- Forces by handling: The load instances include both lifting forces as well as own weights and fouling weights less any parts that are removed before handling;
- Accidental loads: Damage to the net pen which is due to floating parts, shall be inspected. Forces from drift ice or other parts shall be calculated and imposed in areas where it is probable that they will hit.
- Wear due to contact between the net pen and auxiliary systems shall be assessed and documented. In the case of large deformations, the net pens can come into contact with one another. In the event of fouling, the wear forces can be critical with regard to the material damage and resultant tearing.
- Attention shall be paid to the fact that the above-mentioned load effects can be non-linear, and loads must therefore be combined with regard to this. Ice loads shall be assessed and documented for jump catch nets.

It shall be ensured that the net pen tolerates taking up the forces which are transferred from the floating collar when waves result in vertical and horizontal movements in it.

Annex F (informative)

Example of risk analysis, broken down into main components

Table F.1: Risk matrix, used to classify events in a preliminary analysis

Probability	Impact			
	1	2	3	4
4				
3				
2				
1				

	Large risk (unacceptable)
	Medium risk (assess measures)
	Small risk (no measures necessary)

Class	Probability
1	Once every 100 years or more infrequently
2	At least once every 10 years
3	At least once every year
4	At least once every month

Class	Impact
1	Less escape, 1 to 100 fish
2	From 100 to 10000 fish
3	From 10000 to 150000 fish
4	Over 150000 fish

Table F.2 – Risk analysis table

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
Quality assurance of site surveys Quality assurance of site surveys, several current measurement	1	Failure of mooring	Erroneous environmental data	Erroneous wave data Erroneous current data Erroneous main directions Erroneous calculation methodology (Hs, V, x, y) Isolated forces / ideal directions Wrong material parameters Wrong methodology for calculation of strength Without acceleration there is no pull	Breakdown	2	3/4	
					Breakdown	2	3	
					Breakdown	2	3	Quality assurance of site surveys
					Breakdown	2	3	Quality assurance of site surveys
					Breakdown	2	3/4	Establish one analysis methodology for connected load
					Breakdown	2	3	Correct reading of tables
					Breakdown	2		
					Breakdown	2	3	Connected analyses with interaction forces
					Breakdown	2	3/4	Learn from other industries
					Breakdown	2	3/4	Regular cleaning, routine inspection, correct load instances, user handbook
					Breakdown	2	3	Routine inspection, correct load instances, user handbook
					Breakdown	2	3	Routine inspection, user handbook
					Wrong safety factors Increased load Erroneous supporting information for dimensioning Defective assembly of marine fish farm installation Failure of connecting point Unforeseen load			Type certificates The parts are not assembled correctly Defective user handbook / user interface Defective testing of technical solutions in the connecting point
Breakdown								
Breakdown								
Breakdown								
Breakdown	2	3/4	Include the loads we wish shall be tolerated in engineering					

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
	2	Contact with boat/propeller	Wrong handling of boat	Defective training, substandard procedures	Break in single line	3	2	Grating protected propeller on work boat
			Unfavourable configuration / design of boat		Break in single line	3	2	Placing of crane/feeding system vs. propeller
			Bad marking of mooring		Break in single line	3	2	Stricter requirements for marking / light s/lighting
	3	Collision	Unfavourable placing of mooring		Break in single line	3	2	Placing of marine fish farm in relation to the existing environment
			Running into by larger vessels	Bad marking of marine fish farm	Breakdown	2	4	Stricter requirements for marking/ / lights / lighting / reflectors
			Mooring line on water surface		Break in single line	2/3	2/3	Sink all mooring lines connected to the stretching system
	4	Displacement of system	Unfavourable placing of marine fish farm		Breakdown	2	3	Placing of marine fish farm in relation to the existing environment
			Boat or feed raft collided with marine fish farm installation		Break in single line	3	2	Separate moorings/emergency procedures in sudden bad weather
			Depth/length ratio too high		Drifting / Break in single line	3	2	Ensure dimensioning of plough anchor /weight/ bolt fixings
		Low pre-tensioning in some moorings	Attachment / wrong bolt dimension	Attachment / wrong anchor dimension	Drifting / Break in single line	2	2	
					Drifting / Break in single line	3	2	Check dimensioning of bolt attachments, check quality of rock
					Drifting / Break in single line	3	2	Check dimensioning of plough anchor
		Anchor attachment loosens	Attachment / wrong anchor dimension	Attachment / wrong anchor dimension	Chain rusts, i.e. because of different steel quality of chain and shackle / eyelet	2	2	Use tension range
					Wrong dimension for dead weight moorings	3	2	Check dimensioning of weights

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
	5	Rope in anchor line towards the bottom	Wear in the rope on the bottom	Slack in the rope in weak current periods, underwater knolls which get into contact with the line, sharp stones in the transfer chain/rope	Break in single line	2	2	Use chain on the bottom, Olex surveys to find any points of wear, have suitable pre-tension in the mooring line
	6	Wear against other parts	Chafing in the coupling disc / buoy		Break in single line	3	2	
			Chafing in shackle because of fouling		Break in single line	3	2	
			Attachment to floating collar		Break in single line	3	2	
	7	Progressive collapse / break of anchor system	Wrong dimensioning Unforeseen mechanical process Break in a central part High tension level / low useful life		Breakdown	2	3/4	Design
			Erroneous environmental data		Breakdown	2	3/4	User handbook
Floating collar	1	Failure in floating collar	Erroneous dimensioning, calculation of strength	Erroneous wave date	Breakdown	2	3/4	Quality assurance of site surveys
				Erroneous current data	Breakdown	2	3	Quality assurance of site surveys
				Wrong main directions	Breakdown	2	3	Quality assurance of site surveys
				Erroneous calculation methodology (Hs, V, x, y)	Breakdown	2	3	Quality assurance of site surveys
				Isolated forces / ideal directions	Breakdown	2	3/4	Establish one analysis methodology for connected load
				Oversees accelerations	Breakdown	2	3	Establish one analysis methodology for connected load
				Defects in forces from other parts of the structure				Have connected analyses
				Lack of design criteria				
				Wrong material parameters / wrong choice of parameter	Breakdown	2	3	Correct reading of tables
				Heavy fouling	Breakdown	2	3/4	Routine inspection
Increased load	Breakdown	2	3	Routine inspection				
				Icing of marine fish farm	Breakdown	2	3	Routine inspection
				Wrong safety factors	Breakdown	2	3/4	

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/ loss)	Risk analysis:		Suggested measure:	
						Frequ. (1-4)	Impact. (1-4)		
	2	Overloading from the anchor system	Erroneously assembled design of total system	Cage in frame becomes slack in relation to the crowfeet. The ring thereby absorbs forces from the whole of the marine fish farm	Break in single line	3	2	Analyse the total system as one unit	
			Crowfeet too tight on plastic ring		Fracture in floater, collapse of net pen	2	2/3		
			Unfavourable rigidity distribution		Break in single line	3	2		
			Too high pre- tensions		Break in single line	2	2		
			Anchor attachment loosens		Break in single line	3	2		
			Net pen is dimensioned differently than what the floater producer intended						
			Extreme current		Breakdown	2	3		Design
			Extreme wave		Breakdown	2	3		Design
			Overloading from extra equipment		Feed dispenser is not intended for extreme weather	Breakdown	3		Design
			Loss of buoyancy			Breakdown	2		3
	3	Fracture of a part	Icing of marine fish farm		Breakdown	2	3		
			Fouling of floater						
			Wrong attachment of crowfeet		Breakdown	2	3		
			Wrong placing of crowfeet		Breakdown	2	3		
			Wrong design mooring		Breakdown	2	3		
			Wrong dimensioning of mooring		Breakdown	2	3		
			Not dimensioned for the event		Breakdown	2	3		
			Wrong placing of equipment		Breakdown	2	3		
			Wrong assembly of		Breakdown	2	3		
	4	Fatigue			Breakdown	2	3		
	5	Unforeseen mechanical process			Breakdown	2	3		
	6	Overloading from			Breakdown	2	3		

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/ loss)	Risk analysis:		Suggested measure:		
						Frequ. (1-4)	Impact (1-4)			
		extra equipment	equipment Assembly of stretching system without the floater producer taking this into consideration							
	7	Collision	Placing of the marine fish farm		Breakdown	2	3	Placing of the marine fish farm in relation to the existing environment		
Net pen	1	Wrong dimensioning	Erroneous environmental data	Erroneous wave date	Breakdown	2	3/4	Quality assurance of site surveys		
				Erroneous current data	Breakdown	2	3	Quality assurance of site surveys		
				Wrong main directions	Breakdown	2	3	Quality assurance of site surveys		
				Erroneous calculation methodology (Hs, V, x, y)	Breakdown	2	3	Quality assurance of site surveys		
			Empirical, not theoretical knowledge of forces Erroneous methodology for calculation of strength	Isolated forces / ideal directions	Breakdown	2	3/4	Establish one analysis methodology for load		
				No accelerations in the path of forces	Breakdown	2	3	Establish one analysis methodology for load		
				Wrong material parameters	Breakdown	2	3	Correct reading of tables		
				Heavy fouling	Breakdown	2	3/4	Routine inspection		
				Dead fish in net pen	Breakdown	2	3	Routine inspection		
				Icing of marine fish farm	Breakdown	2	3	Routine inspection		
				Wrong safety factors	Breakdown	2	3/4			
				Larger loads than known knowledge	Breakdown	2	3/4	Connected analyses with interaction forces		
				Unforeseen load	Breakdown	2	3/4			
2		Interaction effects between floater and net pen								
3		Interaction effects between net pen and stretching system								

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
	4	Chafing and wear against other parts and equipment	Wrong stretching attachment		Tear in net pen	3	2	
			Wrong assembly of equipment		Tear in net pen	3	2	
		Weight on the inside of the net pen						
		Bad design of dead fish collecting system						
		Possible contact with other parts by unequal load / contact with mooring	Wrong force from the stretching system / wrong mooring	Large rip in net pen	2	3		
		Chafing from stretching rope, chain, lifting rope, crowfeet						
		Wrong assembly of net pen		Tear in net pen	3	2		
	5	Tear due to handling before and during setting out in sea	Transport					
			Handling of net pen in cage					
	6	Predators gnaw tear (seal, cod etc.)	Dead fish in scoop	Lack of strength of net pen in exposed areas	Tear in net pen	3	2	
		Dead fish in folds of net pen	Lack of stretching of net pen					
7	Wrong handling	Wrong construction of net pen		Tear in net pen	2	3		
		Too powerful machinery / equipment		Tear in net pen	2	3		
		Bad marking of net pen		Tear in net pen	2	3		
		Lack of operational routines						
		Wrong procedures for changing of net pen , delivery, drying / disinfection of net pen						
		Wrong procedure/training		Tear in net pen	2	3		

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
	8	Wrong attachment / assembly of net pen	Defective construction of net pen Bad marking of net pen		Tear in net pen	2	3	
			Bad user handbook from the producer Wrong procedures / training	Lack of knowledge on the part of the producer	Tear in net pen Breakdown of net pen	2	3	Standard marking of net pen, attachments points and lifting ropes
	9	Damage due to contact with boat propeller	Wrong boat handling		Tear in net pen	2	3	Training of new boat operators, awareness concerning danger of escape
			Wrongly dimensioned stretching system Comes alongside on the leeward side of current			2	3	
	10	Fouling	Forces caused by normal fouling are not included	No user handbook / follow-up of marine fish farms				
	11	Damage to net pen due to flotsam in the sea	Objects that are floating in the sea	Storms have thrown trees into the sea or broken up ice	Tear in net pen	2	2/3	Regular inspections of net pen to find tears/rips in the net pen, especially after storms and breaking up of ice
	12	Too great forces transferred to net	Shrinkage of net Wrong design / construction of net pen	Handling of a too narrow net pen is difficult	Tear in net pen	2	2/3	Requirement in Standard regarding shrinkage of net
	13	Lack of inspection and maintenance				2	2	
	14	Icing						

Main component	No	Undesirable event: (how)	Causes: (why)	Underlying causes:	Impact: (type damage/loss)	Risk analysis:		Suggested measure:
						Frequ. (1-4)	Impact (1-4)	
Rafts	1	Breaking away from mooring	Wrong dimension of mooring			2	3	
	2	Failure in dimensioning	Chafing / rust of mooring part Erroneous environmental data No strength requirement No stability requirements	Chain and concrete together makes the chain rust		2	3	
	3	Raft sinks and takes the rest of the marine fish farm with it	Raft splits / rusts and takes in water Raft capsizes and takes in water					
				Wrong loading ice and snow		2	3	

Annex G (informative)

Appropriate principles for buoys

Buoys are used which are dimensioned to tolerate submerging at maximum load on the mooring lines. Minimum breaking strength shall be stated.

NOTE 1 On most mooring lines buoys are used to provide extra buoyancy in order to avoid submerging of the floating collar and to provide the mooring line with greater stability. Pressure capacity, i.e. the ability to tolerate submerging, varies from buoy type to buoy type. The capacity depends on the type of filling material.

The following can be satisfied:

- The body of the buoy provides protection for the buoyancy material against external influences such as ice, flotsam, boats, etc. The body of the buoy can be made of steel, aluminium, thermoplastic or reinforced thermoset plastic;
- Thermoplastics shall tolerate a dardrop test of 15 Joule per millimetre thickness, with a ball diameter of 24 mm. Testing is performed at $-20\text{ }^{\circ}\text{C}$, without causing cracks in the material;
- Steel parts which are used in the mountings of the buoy, can be hot dipped with a minimum average thickness of $120\text{ }\mu\text{m}$;
- The main component of the buoy mountings should tolerate a breaking load of 10 times buoyancy;
- The buoy should not be included as an element in the mooring line itself;
- Buoys which delineate the fish farm installation from the area of right of way, shall be coloured in offshore yellow.

Buoyancy material used in fish farm buoys:

- The buoyancy material which is the filling of the buoy can be air, EPS (expanded polystyrene), PU foam (hardened polyurethane foam) or PVC foam;
- Air-filled buoys should only be used where the buoy is not a necessary part of the function of the mooring;
- PU foam should only be used in buoys that are completely sealed;
- EPS and PVC foam should be used in buoys where water can come into direct contact with the buoyancy material;
- EPS has a volume reduction (buoyancy reduction) of max. 8 % of submerged volume. PVC foam has a volume reduction of $< 2\%$ in the case of permanent use;
- The density of EPS foam should be $> 25\text{kg/m}^3$. The foam should tolerate submersion to 5mVs.

Annex H (informative)

Method of calculation of forced deformations of hinged steel installations

The following method of calculation can be used for hinged steel installations:

For hinged installations, marine fish farms which consist of double main, outrigger and intermediate pontoons / bridges, a characteristic shear deformation shall be used for a sea state H_s , between 1 and 3 metres:

$$dh_{char} = 0,011L_p$$

where

L_p is characteristic peak length,

$L_p = 1.57 \cdot T_{p2}$, is a peak period in the range.

For cage systems consisting of single cages in a line, the largest shear deformation for outriggers and intermediate bridges is calculated as:

$$dh = \frac{dh_{char}}{4}$$

This is forced shear deformation over two bridge lengths including any deformation in hinges.

For cage systems consisting of double lines of cages, i.e. with a central middle pontoon the characteristic deformation, dh_{char} , is increased as a function of the number of longitudinal cages as:

$$dh_{char, N \text{ cages}} = dh_{char, 1 \text{ cage}} \cdot N^{0,4}_{\text{cages}}$$

Forced shear deformation over 2 elements is thus stated as:

$$dh = \frac{dh_{char}}{2}$$

Annex I (informative)

Information on hydrogen embrittlement and stress corrosion in connection with galvanising of chains and other steel components

(Scientific contribution from the Directorate of Fisheries by Force Technology Norway regarding fractures in chains at fish farms.)

Summary

This report attempts to clarify circumstances surrounding chain material and failure mechanisms in the event of breaks in the chain.

Probable failure mechanisms are;

- 1) Erroneous heat treatment which results in a material that is too brittle/hard.
- 2) Unfavourable chemical composition. For example, too much carbon will result in a material that can be very brittle in the event of erroneous heat treatment.
- 3) Cold cracking created during forming of the chain at too low temperatures.
- 4) Hydrogen embrittlement, HE, as a result of pickling /acid treatment before galvanising.
- 5) ISC (Hydrogen induced stress cracking) as a result of hydrogen from cathodic protection (galvanising, for example).

In order to avoid damage as a result of items 1 – 3 it is necessary to set higher demands regarding producers and their certificates. It is important to receive documentation that the chemical components are within the limits set for them, and that the heat treatment has been carried out properly. This is paramount to obtaining a material with the characteristics one shall in fact have. It is important to ask the producer to present his procedures and routines so that any errors made can be detected, and so that an acceptance inspection can be performed of chain consignments that are received. Do not purchase chain from a producer who cannot document his production methods.

Concerning items 4 and 5, prevention is the only expedient course. In order to avoid hydrogen penetration during acid treatment, HE, a low hydrogen development must be ensured, or the hydrogen can be "baked" out in subsequent heat treatment.

If carbon steel is to be utilised under water with cathodic protection (galvanising) and one wishes to avoid HISC, it must be ensured that the material has a stress limit of under 550 MPa and that the hardness under no circumstances exceeds 350HV. It is preferable if the steel has a hardness of under 22 Rockwell/237 Brinell/248HV. It is important to also check the hardness in the welding seams, here also with 350HV as an absolute upper limit.

If it is necessary to use steel with a hardness and/or stress limit over the limits stated above, cathodic protection cannot be done. The alternative is to lay en extra corrosion layer of steel, 0.1 – 0.2 mm for each year that the chain is to be protected.

It is recommended to test load the chains to 62.5% of the breaking load since the chains will certainly experience such load during their useful life. It is important to do this after galvanising so that one can test the final strength of each chain link, since a chain is only as strong as its weakest link. In addition, hardness and minimum impact resistance must be verified through Vicker's hardness test and the Charpy test respectively.

Annex J (informative)

Conversion to sizes of hexagonal mesh

Table J.1 can be used for conversion from square mesh to regular hexagonal mesh

Table J.1: Conversion table for mesh side and mesh size from square mesh to hexagonal mesh, assuming the same mesh opening and twine thickness

Square mesh (S net)		Hexagonal mesh (H net)		
mesh side mm	mesh lenght mm	mesh side mm	mesh lenght mm	mesh width mm
42,0	84,0	28,0	112,0	56,0
40,0	80,0	26,7	106,7	53,3
39,0	78,0	26,0	104,0	52,0
38,0	76,0	25,3	101,3	50,7
37,0	74,0	24,7	98,7	49,3
36,0	72,0	24,0	96,0	48,0
35,0	70,0	23,3	93,3	46,7
34,0	68,0	22,7	90,7	45,3
33,0	66,0	22,0	88,0	44,0
31,0	62,0	20,7	82,7	41,3
30,0	60,0	20,0	80,0	40,0
28,5	57,0	19,0	76,0	38,0
27,0	54,0	18,0	72,0	36,0
26,0	52,0	17,3	69,3	34,7
25,0	50,0	16,7	66,7	33,3
24,0	48,0	16,0	64,0	32,0
23,0	46,0	15,3	61,3	30,7
22,5	45,0	15,0	60,0	30,0
22,0	44,0	14,7	58,7	29,3
21,0	42,0	14,0	56,0	28,0
20,0	40,0	13,3	53,3	26,7
19,5	39,0	13,0	52,0	26,0
18,5	37,0	12,3	49,3	24,7
17,5	35,0	11,7	46,7	23,3
16,5	33,0	11,0	44,0	22,0
15,5	31,0	10,3	41,3	20,7
15,0	30,0	10,0	40,0	20,0
14,0	28,0	9,3	37,3	18,7
13,0	26,0	8,7	34,7	17,3
12,5	25,0	8,3	33,3	16,7
12,0	24,0	8,0	32,0	16,0

Square mesh (S net)		Hexagonal mesh (H net)		
mesh side mm	mesh lenght mm	mesh side mm	mesh lenght mm	mesh width mm
11,5	23,0	7,7	30,7	15,3
11,0	22,0	7,3	29,3	14,7
10,5	21,0	7,0	28,0	14,0
10,0	20,0	6,7	26,7	13,3
9,75	19,5	6,5	26,0	13,0
9,5	19,0	6,3	25,3	12,7
9,25	18,5	6,2	24,7	12,3
9,0	18,0	6,0	24,0	12,0
8,75	17,5	5,8	23,3	11,7
8,5	17,0	5,7	22,7	11,3
8,0	16,0	5,3	21,3	10,7
7,75	15,5	5,2	20,7	10,3
7,5	15,0	5,0	20,0	10,0
7,0	14,0	4,7	18,7	9,3

Annex K (informative)

Requirement for further research and development

K.1 Environmental provision on current and wind based on measurements

At many locations along the Norwegian coast, the current varies so much over a yearly cycle that one can risk underdimensioning the current load significantly. Scientific documentation is required here.

K.2 Exemplification with the aid of calculated cases

The practical effect of parametric choice in the form of calculated examples cases should be documented.

K.3 Review and supplementary calculation of breakdown

To make a supplementary calculation of a breakdown case will provide useful information that the fish farming industry has built in the correct priorities in order to avoid large escape occurrences.

K.4 Review of safety factors, flexible/less flexible structures

The safety factors in dimensioning should be able to be supported by empirical data.

K.5 Dimensioning limit states

It is important to perform a critical evaluation of which limit states are to be given priority. This is to avoid an extensive verification which will possibly be very resource-intensive.

K.6 Wave and current loads on the net pen . Categorisation

There is no documented scientific connection between current and wave loads on the net pen and choice of dimension classes.

K.7 Reduction of net volume as a function of current velocity

It should be sought to find out how the volume of a net pen changes in relation to the forces imposed by various current velocities.

K.8 Stretching system, loads on net and rope as well as establishment of dimension class

It should be sought to find out how the stretching system affects the requirements for strength on the net twine and rope as well as establishment of dimension class.

K.9 Stability, safety and mooring of feed rafts in high seas

The requirements regarding stability are in no manner synchronised with the degree of exposure of feed rafts, i.e. the danger of water washing over, relative movements etc., is dependent on the degree of exposure.

K.10 Operation of wellboat and workboat in the vicinity of ropes and nets

A review of dangerous operations, i.e. maximum use of thrusters in the vicinity of net pens or ropes, is of great importance for prevention of escape.

K.11 Expected icing volume per 24-hour period or equivalent

Expected icing volume per 24-hour period or equivalent should be explained and be included in guidelines / assessments.

K.12 Method for calculation of dimension class in relation to net design

It should be sought to find a better basis for establishing dimension class for a net pen on the background of net design (i.e. cone shaped net or cylindrical shaped net).

K.13 Design and choice of material connected to net pens

It should be sought to find a set of tables for design of net pens, based on calculations and new developments instead of experiences from the "old industrial standard" (empirical design).

K.14 Knowledge of long-link, galvanised chain

Obtain more knowledge of long-link, galvanised chain for use in the fish farming industry. There is a necessity for a documented, scientific basis as supporting documentation for establishment of specific requirements and description of suitable testing methods which reflect the actual use, and the forces chains are exposed to in a fish farming context. I.e., not only stretch testing in relation to breaking. This will entail methodology development.

Literature

Det norske Veritas: DNV OS-E301

Directorate of Fisheries: Force Technology report. Breaks in chains in fish farming installations MAIN REPORT August 2009

- Norsk Standard og guider fastsettes av Standard Norge. Andre dokumenter fra Standard Norge som tekniske spesifikasjoner og workshopavtaler publiseres etter ferdigstilling uten formell fastsetting.
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- Inntektene fra salg av standarder som Standard Online AS står for, utgjør en stor og avgjørende del av finansieringen av standardiseringsarbeidet i Norge.
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Appendix III
Aqualine User Manual –
Aqualine Froya Ring Floating Collar



User Manual

Aqualine Froya Ring
floating collar





USER MANUAL

AQUALINE FRØYARING – FLOATING COLLAR

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USER MANUAL

AQUALINE FRØYARING – FLOATING COLLAR

1 Introduction

This user manual describes important information on how the floating collars and other components delivered by Aqualine AS are to be transported, handled, installed, inspected and maintained.

At the end of the user manual there are forms for inspection, control, reporting of deviations and repair attached. These are intended as templates with the necessary points for checks and follow-up of the floating collar.

Take contact with Aqualine AS for ordering of spare parts and service.

If you find elements that have been poorly explained, please contact us; we are more than willing to provide further guidance and advice.

2 Aqualine og Aqualine FrøyaRingen

Since 1980, Aqualine AS has delivered floating collars to the fish farming industry in Norway and internationally. For our design and concepts, site-specific environmental specifications are taken into account. Furthermore, as Aqualine AS deliver complete cages with nets, collars and mooring, possible risk aspects influencing operations of the constructions are carefully evaluated.

Within this document there some references made to standard NS9415. This standard is governing for all design/production and operation of fish farm constructions in Norwegian Sea. Please note that requirements are implemented in general design, however foreign customers may have other requirements for the equipment.

The site class governing a delivery is indicated on the product certificate for each individual floating collar. Here, also the applicable requirements to maximum cage net depth and allowed load per mooring point and other important information have been included.



USER MANUAL

AQUALINE FRØYARING – FLOATING COLLAR

2.1 Contacts in Aqualine AS

	Tel.	Fax.
Switchboard:	73 80 99 30	73 80 99 40

Please visit our web-site to get in touch with the right person:

www.aqualine.no/kontakt/ansatte

Web site: www.aqualine.no

E-mail: aqualine@aqualine.no

3 Definitions

Reference NS9415-2009 contains all definitions.

4 HSE Health, Safety and Environment

Work operations on a net cage must be mapped and risk assessed, and the necessary safety measures must be initiated. This should at least include:

- The possibility to save oneself in case you fall into the sea
- The risk of falling
- That the installation is ergonomically prepared, hereunder gangways and railings
- Access with boat
- Requirements and routines for maintenance and inspection
- Appropriate and good lighting
- Work operations when using a crane

5 Main Principles Floating Collar

5.1 General Description of the Construction

The construction consists of:

- The floating collar has double floater tubes and railing tubes in polyethylene plastic.
- All welded steel clamps or injection moulded plastic clamps have been mounted on the tubes.
- The clamps are anchored with a dimensioned main supporting system in the horizontal plane, see Figure 1. The main supporting system consists of steel clamps/plastic clamps connected to steel rods/chain/fibre ropes which handles the forces round the circumference of the floating collar.

- Separate steel mooring clamps handles the loads from the moorings which are distributed around the circumference by means of this construction. The client may choose another option, but then the customer must evaluate the risk of this option.
- The steel clamps counteract any ovalization of the floater tubes. This local buckling is prevented and the flexibility of the floater tubes is maintained.
- By fastening the cage net onto clamps, an even distribution of the net load into the system is ensured.
- Bushings between the steel clamps and the floater tubes reduce friction. The floater tubes thus move freely inside the clamps, both in terms of rotation and longitudinal movement.
- There is expanded polystyrene in both floater tubes to maintain the buoyancy in case of any damage or puncture.



Figure 1: Load Distribution around the circumference

5.2 Clamps

The floating collar is assembled by means of various types of clamps. They have different applications and the following should be observed when using a floating collar:

- The floating collar should only be moored in dedicated steel mooring clamps.
- The sinker tube, if any, should only be fastened in dedicated clamps.
- The cage net should preferably be fastened at lowest point at the railing post.
- The capacity of the mooring clamps, allowed torque and the forces on the railing posts and the maximum weights on the sinker tuber/distention system, are indicated in the floating collar's product certificate.

5.3 Marking of Floating Collar

Every delivery will have its unique serial number which identifies the products. The floating collars are marked with a unique marking tube in plastic and in addition, the serial number is stamped into the 4 mooring clamps.

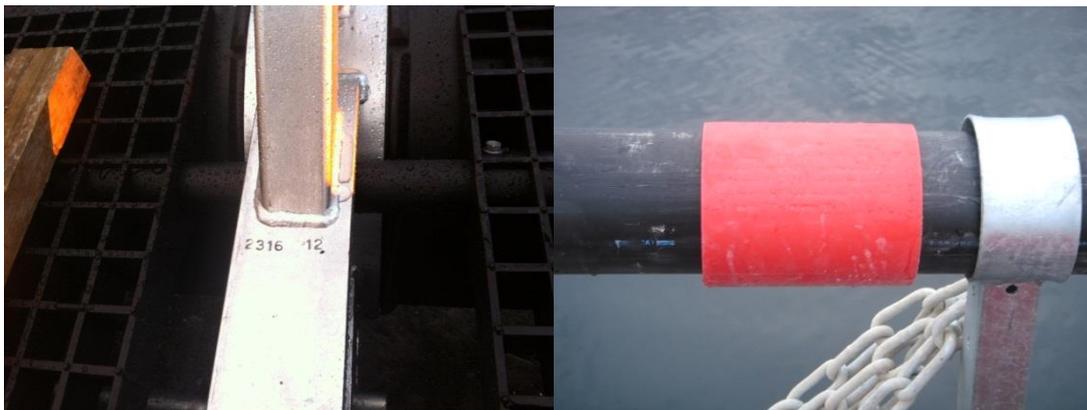


Figure 2: Marking of mooring clamps and marking tube.

The marking tube is permanent fitted with the following readable information:

1. Certificate no. NSAS 006
2. Type no./Product
3. Manufacturer
4. Approved in accordance with NS 9415
5. Max. significant wave height H_s
6. Max. current V_c
7. Payload
8. Dimensioning time of use
9. Production date and year
10. Project no.
11. Serial number

5.4 Net Buoyancy Floating Collar

In the product certificate, the net buoyancy of the floating collar without any accessories is described.



USER MANUAL

AQUALINE FRØYARING – FLOATING COLLAR

5.5 Specification Floating Collar

Type	315	400	450	500	630
Relevant perimeters	60-120m	80-160m	110-180m	120-200m	140-+++m
Relevant diameters *	19,1-38,2m	28,6-50,9m	35,0-57,3m	38,2-63,7m	44,6-+++m
Surface	286-1146m ²	645-2037m ²	963-2578m ²	1146-3183m ²	1560-+++m ²
Floater tube	Ø 315mm	Ø 400mm	Ø 450mm	Ø 500mm	Ø 630mm
Hand rail	Ø 125mm	Ø 140mm	Ø 140mm	Ø 140mm	Ø 160mm
Expanded polystyrene	In both floater tubes	In both floater tubes			
Mooring fastening points in steel	Standard	Standard	Standard	Standard	Standard
Plastic bushing	Standard	Standard	Standard	Standard	Standard
Fender	Standard	Standard	Standard	Standard	Standard

* The circumference and diameters are measured on the inside of the inner floater tube.

6 Preparation

6.1 Assembly / Construction at Customer Site

When mounting floating collars at customers site, where the customer is responsible for the assembly area and the facilities, parts for the assembly will arrive in advance of the operation in time. In these cases, it is important that the parts are unloaded and stored in an appropriate and suitable area, so that the parts are not damaged and/or deformed. Care must be taken so that the area for the assembly is not blocked by the parts. It is the customer's responsibility to take care of the parts during the whole assembly period.

6.2 General Requirements

- The floating collars must only be used in accordance with the site survey report.
- The customer must make sure that the floating collar, accessories is delivered according to the contract, and that no components are damaged.
- If the delivery includes a sinker tube; this one is then delivered together with the floating collar.

6.3 Towing

- Floating collars should be towed without cage net attached.
- The floating collar is fastened with a crowfoot to a towing hawser, distance about 20 meters.

The bridle is fixed to the floating collar's mooring clamps. We recommend three parts for the front floating collar, and a minimum of two for the rest.

- When towing several floating collars a hawser which goes from the bridle on the first floating collar to the bridle of the last floating collar should be applied.
- When towing, the hawser must be able to run unrestricted through the floating collars; this is best by letting the hawser go through loops/rings which are fixed in separate clamps. See Figure 3.



Figure 3: This photo shows an example of how the hawser and the bridles are fixed to the floating collars.

- The hawser from the towboat to the first floating collar should be at least 150m to reduce the influence of the propeller's slipstream.
- As a safety precaution in case anything should happen with the hawser or the bridles, we recommend to secure the tow with slack ropes on each side parallel with the main hawser. See "sikringstau" (securing ropes) on Figure 4.
- To prevent ovalization of the floating collars, ropes should be fitted in the towing direction between the inner floater tubers, see "krysstau" (cross ropes" on figure 4.
- All knots and ropes should be secured by two inserts and seized.
- If a sinker tube has been fitted to the floating collar, the sinker tube may be fastened on top of the floating collar during towing. See also the user manual for the sinker tube system.
- If the tow is made with the sinker tube suspended under the floating collar, you must make sure that the sinker tube suspension system, the floating collar and/ or the sinker tuber is not exposed to potential damage.
- The relative towing speed must not exceed 3 knots.
- During moving of the floating collar with cage net, the speed should be adapted so that current/waves do not exceed the floating collars maximum allowed significant wave height and current.

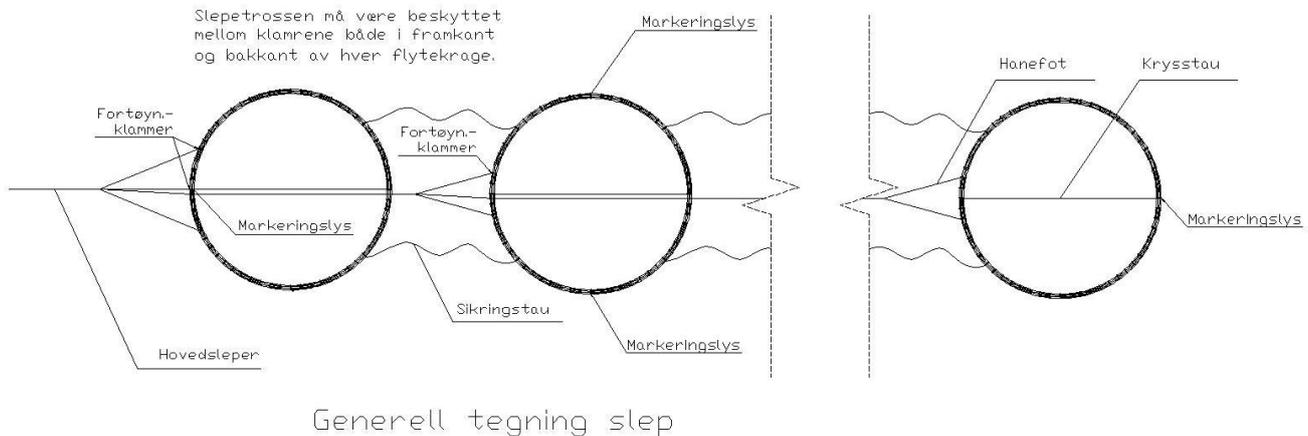


Figure 4: The figure shows an example of how the hawser and the crowfoots are fixed to the floating collars.

6.4 Installation into Mooring System

When it comes to the maximum allowed payload for the mooring connections, we refer to the product certificate.

- It is assumed that the mooring system is dimensioned for the same allowed significant wave height and current, or higher.

6.4.1 Mooring in standard mooring clamps

If a shackle is used for mooring of the floating collar with standard mooring clamps, all shackles must be secured with a plastic coated locking wire or other securing system which does not cause corrosion. Do NOT use cotter pins of stainless material.



Figure 5: The photo shows an example of fastening of mooring in standard mooring clamps. Shackle secured with a plastic coated locking wire.



Figure 6: The photo shows a floating collar with injection moulded clamps and steel mooring clamps.

6.4.2 Mooring in tube type mooring clamps

As an alternative to the standard mooring clamps with a lug, the fastening is made by means of a bridle through a tube (chain hole) which passes through the clamp. This clamp may be used in the following manner.

- Chain and shackle dimensions must be 16mm or 19mm galvanized alloy chain with 6.5T H shackle.

- The chain from the bridle is pulled from the beneath clamp and is secured with a shackle as shown on the photo below. It is important that the shackle rests properly against the cross plate on the chain tube.



Figure 7: This photo shows an example of fastening of mooring in tube type mooring clamps. The chain is secured by means of a cross plate and shackle.



Figure 8: Underneath the clamp, it is very important that the chain act like a hinge as show non the picture. No bending loads on the chain link legs.

- If the bridle consists of other chain dimensions or of ropes, the bridle should be spliced with minimum 3m 16mm or 19mm preferably Gunnebo long linked galvanised chain for fastening in the mooring clamp.

6.5 Frame Mooring

- The bridles from the mooring system is fastened in the mooring clamp on the floating collar.
- All crowfoots should be of the same type of rope/chain and have the same dimension.
- The rings should be placed as close to the centre relative to the frame as possible, and there should be a certain slack in the bridles, see Figure below.
- Pre-tensioning: The mooring frame must be constructed so that the pre-tensioning forces are distributed on the frame system and not in the bridles.

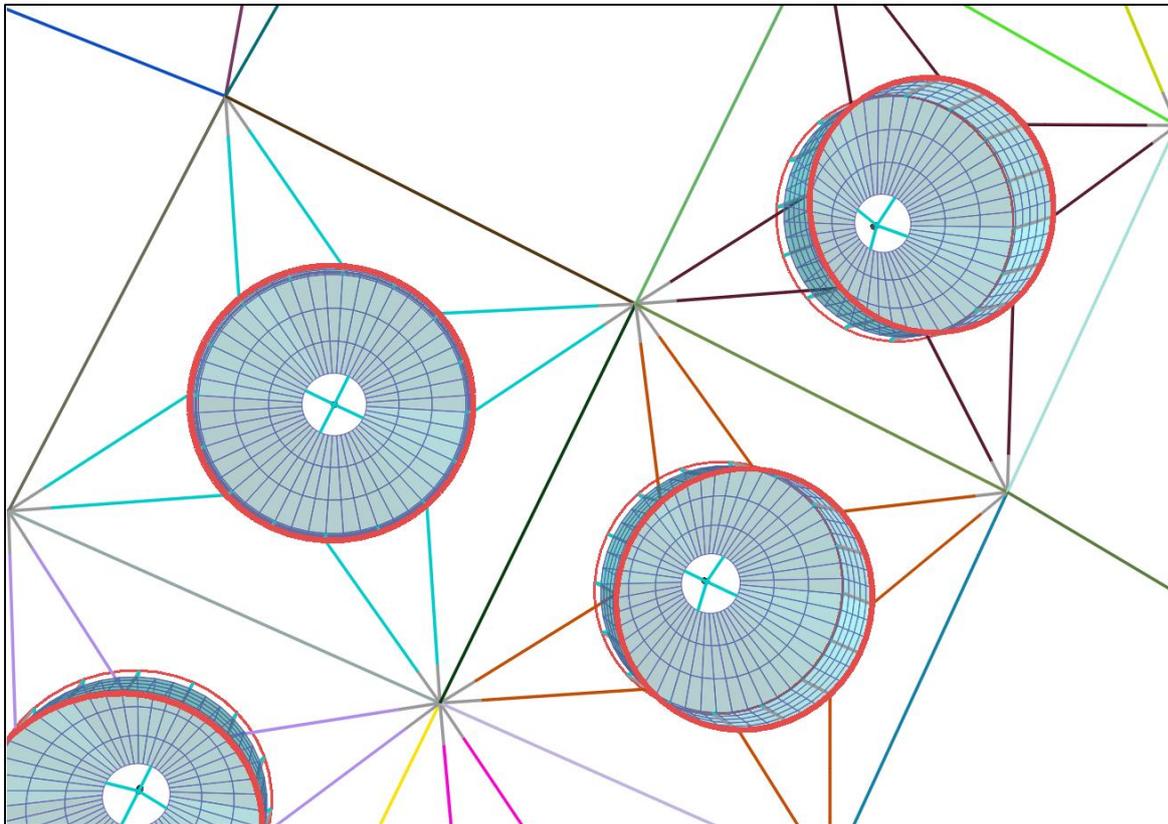


Figure 9: Rings in centre of Frame Mooring (Picture taken from Analysis Software Aquasim)

6.6 Fastening of the cage net to the Floating Collar

Fitting of the cage net is made according to the specifications from the manufacturer of the cage net. When using a sinker tube system, reference is made to specific manual for such system.

- The fastening points on the floating collar are preferably at the lower part of the railing post.
- If the cage nets fastening points is not adapted to the floating collar's clamps, you may fasten the cage net in the floater tubes between the clamps. This may be done in 2 ways;
 - 1) The rope passes over the inner floater tube and then under the outer. Tied between the floater tubes around the outer.
 - 2) The rope passes over both floater tubes and is tied between the tubes around the outer one.
- In order to reduce the risk of gnawing, the rope should be padded. Make sure that there are openings in the gangway or move the gangway somewhat. By tying a rope on the railing post on each side of the fastening of the cage net, you will reduce the sideways displacement of the fastening of the cage net.
- We recommend using cage nets, which are adapted to the floating collar so that all the fastening points are suited for the Clamps on the floating collar.



Figure 10: These photos are for illustration purposes only. Fastening of the cage net between the railing posts.

- When using a sinker tube, all the fastening points of the cage net to the floating collar should be fastened before lowering the sinker tube.
- The jump net for the cage net should, as a starting point, not be suspended in the cage net hooks during operation.

7 Accessories

7.1 Aqualine FrøyaRing Sinker Tube

Aqualine FrøyaRing floating collars are also delivered with an Aqualine FrøyaRing sinker tube system for distention of the cage net. Aqualine AS has long-term experience with delivering and operating sinker tubes. A sinker tube contributes to maintaining that the shape, and thus also the size, of the cage net, is not altered materially in localities which are subjected to a lot of current.

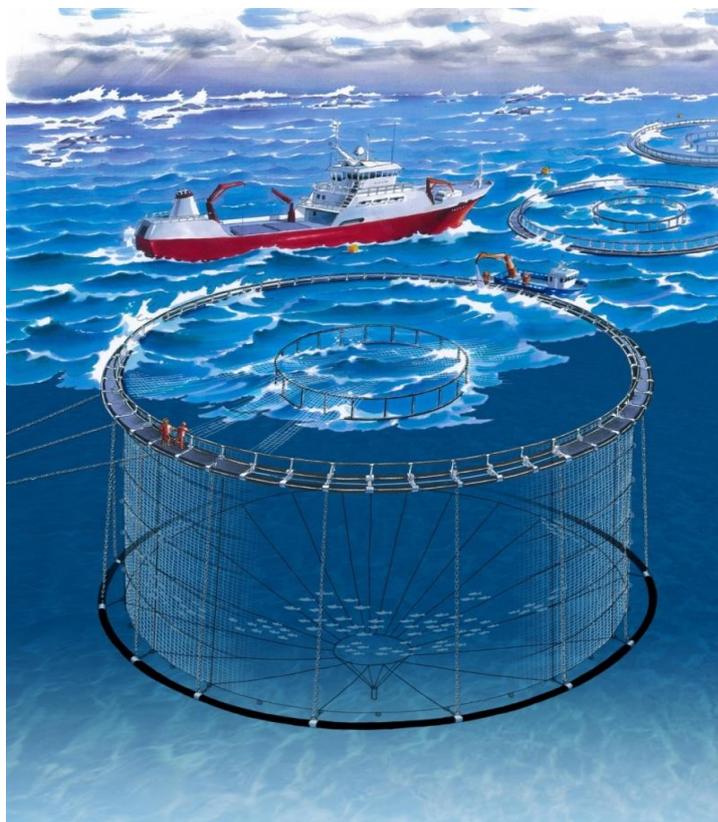


Figure 11: Aqualine FrøyaRing flytekrage med bunnring

The Aqualine FrøyaRing sinker tube system is described in a separate user manual.

7.2 Aqualine gangway

Gangways provide the safest and best working environment for the personnel at site in all types of weather. Gangways also increase the efficiency, as the tasks may be carried out both easier and faster.

Aqualine gangways:

- Designed to avoid slip-incidents.
- Fitted so that they do not interfere with the flexibility of the net cage.
- May easily be fitted at a later stage on previously supplied net cage systems.



Figure 12: Gangway

The gangway should not be used for storage of weights etc.

7.3 Aqualine FrøyaRing anti-bird net system

Aqualine AS delivers anti-bird net systems.



Figure 13: The photo shows an anti-bird net system inside a floating collar.

7.4 Rods for anti-bird nets

If you will use rods to keep the anti-bird net tensioned, then these must be installed so that they do not introduce much bending moment on the railing post. The allowed moment on the railing post is indicated in the floating collar's product certificate.



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AQUALINE FRØYARING – FLOATING COLLAR

7.5 Automatic Feeding System

Automatic feeders on rafts may be fitted to the floating collar under the assumption that load calculations have been made. See the supplier's user manual for this. In the product certificate for the floating collar in question, we will be able to enter which type of automatic feeder it is approved for and for which environmental loads this applies to.

7.6 Other Accessories

Aqualine should be contacted before installation of other optional accessories which may influence on the floating collar's movements, buoyancy, load, damages etc.

Equipment which is installed after permission has been given by Aqualine must be fastened in a proper way.

The main components of the floating collar must not be removed or repositioned for installation of optional accessories.

Aggregate and electrical equipment must be well insulated from the floating collar's steel components to prevent galvanic corrosion.

Zinc anodes may be used to extend the service life of the floating collar's steel components. These may be replaced when needed.

Aqualine AS take no responsibility for accessories supplied by other suppliers. This is for the clients own risk.

8 Operation

8.1 Mooring of boats

Fish farming boats (workboats) and well boats should be moored so that they do not risk damaging the cage net, mooring or floating collar.

The floating collar should be marked at areas where it is practical and safe to perform mooring of boats.

Fish farming boats less than 15 meters length should be moored at lower points on clamps at non-vertical support rods if it is made out of a square steel profile. Do not perform mooring in railing tubes, up on the railing post, in chains or rods.

You should avoid mounting ropes in the floating collars mooring lugs. These items must be clean and visible for inspection.

Fish farming boats over 15 meters length and well boats should not have their main mooring in the floating collar as it may cause too high loads. These should be moored in the system mooring at dedicated point.

8.2 Delousing

The floating collar is dimensioned for use of closed tarpaulin down to 7m when delousing. This assumes that the use of a tarpaulin is made within the following environmental loads:

Dim. Floater tube	Sign. Wave Height, H_s [m]	Current, V_c [m/s]
315	0,5	0,15
400	0,75	0,2
450	1,0	0,25
500	1,0	0,3
630	1,0	0,5

Table 1: Environmental loads when use of closed tarpaulin.

8.3 Lifting of floating collar

For lifting, we recommend 2 pcs wide lifting straps with a space in-between of around 3m or more, so that there are at least 2 clamps between the lifting points. The straps should pass under both floater tubes, not under the sinker tube. Working angle: $\beta < 30^\circ$. (I.e. the angle between the strap and a vertical line). Maximum lifting height from the water surface is 3m.



Figure 14: The photos are for illustration only. Wider lifting straps should be used for lifting.

Dim. Floating Tube [mm]	Width of lifting Strap [mm]
315	80
400	100
450	110
500	120
630	150

Table 2: Minimum width of the lifting strap on lifting floating collar.

8.4 Cleaning

After each launch, it is preferred to clean the floating collar and the sinker tube, if any. It is customary to use specially designed hosing rigs to remove fouling and shells. If you have to use a crane, you should make sure that the floating collar hangs safely in the lifting straps and that you do not stay underneath hanging loads.

If you use disinfectants and/or other chemicals, you must ensure that the compound will not damage the floating collar's components.

8.5 Measures to be used when landing and launching

Space requirements: The area must be able to accommodate the floating collar and have a free way of passage of around 10 meters.

For landing, you may use cranes or other appropriate lifting equipment, see chapter 8.3. To lift the whole floating collar, you will need big cranes and this is not practical if the floating collar has a circumference of 90 meters and larger. The most common thing is to use a combination of lifting and pulling force.

The floating collar may be ovalized by stretching a rope across the floating collar in order to make it more practical to land it. Make sure that the tubes bending radius of the tubes is within allowable limits. (Maximum allowed diameter increase during handling: 15 %)

Do not put equipment on top of the floater tubes; make sure that no sharp edges on the machines and the ground does not damage the floater tubes.

9 Storage

In case of storage, the floating collar should be stored to avoid damage on the collar.

9.1 Storage at sea

On storage at sea, the floating collar should properly moored and marked for general sea traffic.

9.2 Storage on shore

For storage on shore, the ground must be even to avoid point loads on the floater tubes. See the product certificate regarding area.

10 Unwanted Incidents

10.1 Extreme Situations

If, during extreme situations, the floating collar should be damaged, it will normally not sink as it is filled with expanding polystyrene.

The operations manager must assess whether the floating collar must be repaired immediately or if the repair may wait. We recommend contacting Aqualine AS to discuss the issue. Such incidents should be logged for inspection and maintenance, see appendix 1-7.

Subsequent to weather conditions and incidents which may have caused damage to the equipment beyond the ordinary, one should, as a minimum, carry out a monthly control of the floating collar.

10.2 Rupture or damage to the floater tube

If a rupture or damage occurs to parts of the floating collar, the construction will normally keep its shape and prevent total collapse. The clamps which are connected to a dimensioning main supporting system in the horizontal plane, will keep the construction together. The floating collar's remaining capacity will normally prevent that the cage net will collapse.

Aqualine FrøyaRingen floating collars are delivered with floater tubes filled with rods made out of expanded polystyrene. The rods are there to maintain the buoyancy in case of damage or puncture. In case of punctures in both floater tubes, the net buoyancy is reduced in accordance with table 2:

Dimension floater tube [mm]	Reduction of net buoyancy in case of puncture of both floater tubes
315	About 9%
400	About 4%
450	About 28%
500	About 39%
630	About 50%

Table 3: Reduction of net buoyancy in case of puncture of both floater tubes.



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10.3 Tidal variations and storm surge

Tidal variations and storm surges are not critical for the floating collar.

10.4 Ice and Snow

Ice and snow may cause great loads on the construction. The load effect from icing is primarily connected to loss of buoyancy. Build-up of ice and snow should primarily be removed by means of a rubber hammer/wooden mallet. Ropes for fastening the jump net to the floating collar should have low breaking strength. On great build-up of ice on the jumping net, the ropes will break and the jumping net will fall into the water and the ice will melt.

On localities where icing and floating sea ice may occur, the fish farmer must have emergency plans/measures for removing ice.

11 Waste handling

All the components in the floating collar can be recovered/recirculated. May be delivered to an approved waste handling plant.

12 Inspection, maintenance

12.1 Logging

All inspections, maintenance, repairs and incidents should be logged in accordance with the check points in chapter 0 and the forms in Attachments 1 to 7.

12.2 Modifications

Each modification must be managed and carried out by a qualified Aqualine installer. Agreement about such service must be made with Aqualine AS.

Old product certificate expires/are terminated and filed. New product certificate is established and distributed.

Any modification must be made in accordance with the specifications and requirements to the new type of floating collar.

12.3 Spare Parts

The correct spare parts are identified and procured according to data on the product certificate. Replacement of spare parts must be discussed with Aqualine AS, to ensure that the correct/appropriate parts are used.

13 Sjekkpunkter

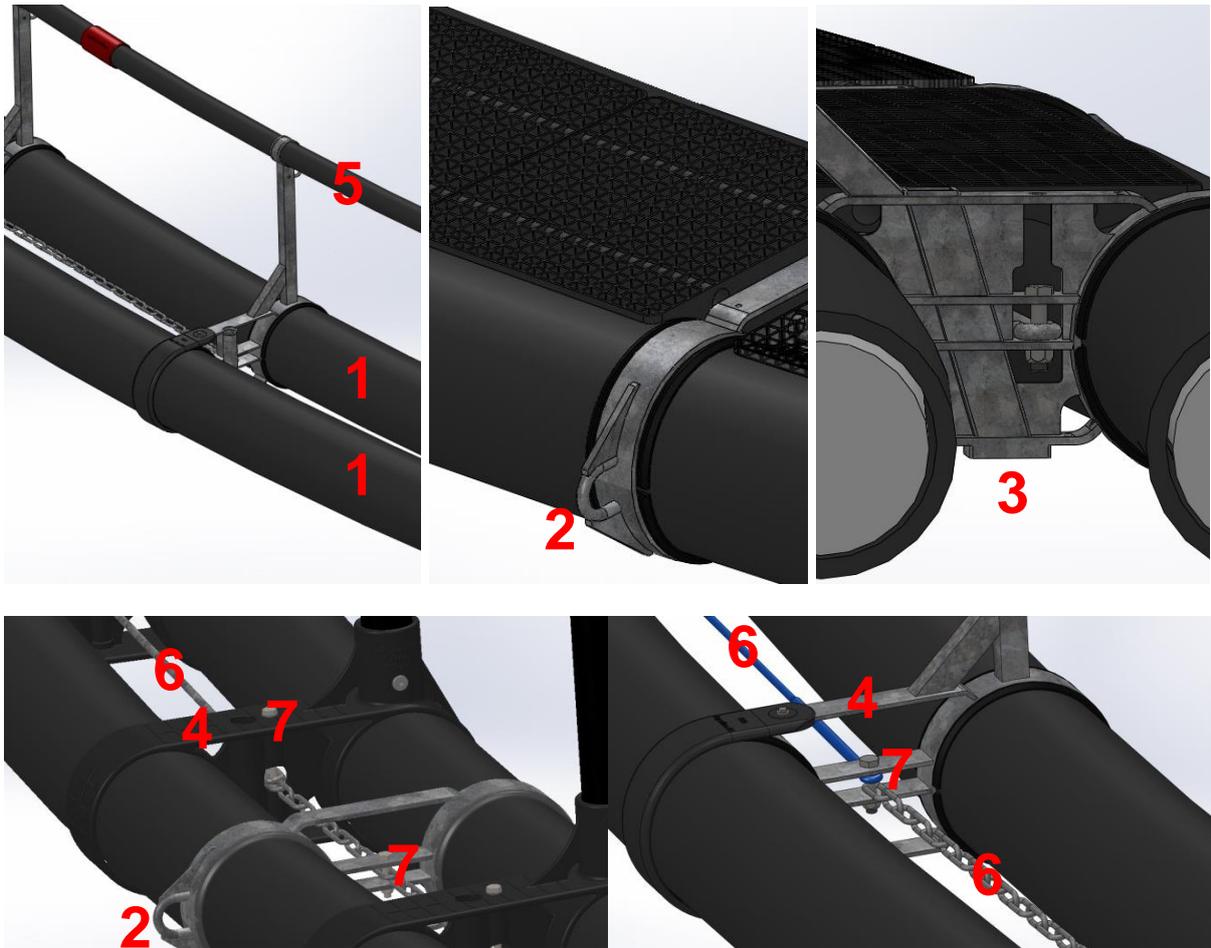


Figure 15: The illustrations show checkpoints for inspection and maintenance.

13.1 Ettersyn og vedlikehold på flytekrage

THE MAINTENANCE SHOULD BE PERFORMED AT THE INDICATED INTERVALS			DAILY	WEEKLY	MONTHLY	3. MONTH	ANNUALLY
Checkpoint	What	How					
1	Floater tube	Check the floater tube for cuts, breaks and ruptures.					
2	Mooring clamps with bow	Check the mooring clamps with bushings for ruptures/ cracks. Check whether the mooring lug is bent or whether there is a rupture in the mooring lug. Also check for wear and tear on mooring lug and clamp.					
3	Mooring clamps with tube hawse hole	Check the mooring clamps with bushings for breaks/cracks.					
4	Steel/plastic clamps	Check the clamps with bushings for any ruptures in the railing post.					
5	Railing tube	Check for ruptures in the railing tube.					
6	Trusses/chains/ropes*	Check whether Trusses/chains/ropes in the main supporting system are tight and are free for deformations or ruptures.				*	
7	Bolt/plug connections	Check whether the Trusses/ chains/ropes in the main supporting system are free from deformations or ruptures.					

* Tighten the main supporting system after 3 months use and at the annual check if it is necessary. This may be done, for example, with the aid of a chain hoist on the chain in the main supporting system. See Figure below.



Figure 16: Tightening of chain with chain hoist.

Anyone who performs inspections and maintenance should have passed the company's internal training and made himself familiar with the product and understood the product's user manual.



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AQUALINE FRØYARING – FLOATING COLLAR

As a minimum, a monthly check should be performed after a period of bad weather.

PS. When it comes to the annual control, it is most practical to replace parts after every launch. This may be extended to 2 years assuming that the check is made close to the time for the floating collar to be deployed for service.

14 References

14.1 NS9415, the most recent applicable, as well as underlying standards

14.2 The Nytec Regulations, the most recent applicable



Appendix 1: Log inspection and maintenance, daily

Log form inspection and maintenance, daily				
Name:		Type:	Prod. No.	Purchased Year:
What	How		Month	Sign.

SIGN. MONTH				
MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY

User Manual for the form:

If there are deviances, you should refer to a number on the repair not/deviation report and the deviation should be entered into the event log.

The person who carries out the inspection and maintenance must have passed the company's internal training and made himself familiar with the product and understood the product's user manual.

Appendix 2: Logg inspection and maintenance, weekly

Log form inspection and maintenance, weekly				
Name:		Type:	Prod. No.	Purchased Year:
What	How		Month	Sign.

WEEK	SIGN.								
1		12		23		34		45	
2		13		24		35		46	
3		14		25		36		47	
4		15		26		37		48	
5		16		27		38		49	
6		17		28		39		50	
7		18		29		40		51	
8		19		30		41		52	
9		20		31		42		53	
10		21		32		43			
11		22		33		44			

User Manual for the form:

Every week the form is to be signed with "OK" and initials. If there are deviances, you should refer to a number on the repair not/deviation report and the deviation should be entered into the event log.

The person who carries out the inspection and maintenance must have passed the company's internal training and made himself familiar with the product and understood the product's user manual.



Appendix 3: Log inspection and maintenance, monthly

Log form inspection and maintenance, monthly				
Name:		Type:	Prod. No.	Purchased Year:
What	How		Month	Sign.
Trusses/chains/ropes	Check whether trusses/chains/ropes in the main supporting system are taught and are free for deformities or ruptures.			
Bolt/plug connections	Check whether the trusses/chains/ropes in the main supporting system are free from deformations and ruptures.			

SIGN. YEAR					
JANUAR		FEBRUAR		MARS	
APRIL		MAI		JUNI	
JULI		AUGUST		SEPTEMBER	
OKTOBER		NOVEMBER		DESEMBER	

User Manual for the form:

Every month the form is to be signed with "OK" and initials. If there are deviations, you should refer to a number in the repair note/deviation report and the deviation should be entered into the event log.

The person who carries out the inspection and maintenance must have passed the company's internal training and made himself familiar with the product and understood the product's user manual.

Appendix 4: Log inspection and maintenance, every 3rd month

Loggskjema ettersyn og vedlikehold, every 3 rd month			
Name:	Type:	Prod. No.	Purchased Year:
What	How	Month	Sign.
Trusses/chains/ropes	Check whether trusses/chains/ropes in the main supporting system are taught and are free for deformities or ruptures.		

SIGN. YEAR					
JANUAR		FEBRUAR		MARS	
APRIL		MAI		JUNI	
JULI		AUGUST		SEPTEMBER	
OKTOBER		NOVEMBER		DESEMBER	

User Manual for the form:

Every day the form is to be signed with "OK" and initials. If there are deviations, you should refer to a number in the repair note/deviation report and the deviation should be entered into the event log.

The person who carries out the inspection and maintenance must have passed the company's internal training and made himself familiar with the product and understood the product's user manual.

Appendix 5: Log inspection and maintenance, annually

Log form inspection and maintenance, annually				
Name:		Type:	Prod. No.	Purchased Year:
What	How	Month	Sign.	
Floater tube	Check the floater tube for cuts, breaks and ruptures.			
Mooring clamps with bow	Check the mooring clamp with bushings for ruptures/cracks. Check whether the mooring lug is			
Mooring clamps with chain hole	Check the mooring clamp with bushings for ruptures/cracks.			
Steel/plastic clamps	Check the clamps with bushings for any ruptures in the railing post.			
Railing tube	Check for ruptures in the railing tube.			
Main support system	Tighten main support system			

Bruksanvisning skjema:

Every year is to be signed with "OK" and initials. If there are deviances, you should refer to a number on the repair not/deviation report and the deviation should be entered into the event log.

The person who carries out the inspection and maintenance must have passed the company's internal training and made himself familiar with the product and understood the product's user manual.



Appendix 6: Repair note / deviation report

		NO.	
Name:	Type:	Prod. No.	Purchased Year:
Description of the defect/maintenance which ought to be done:			
If possible, please suggest what ought to be done:			

Date and signature, reporter

Repair Describe what has been done and the costs related (Spent time + parts), rejects etc.:	
Was the repair successful:	New measure on repair note No.:

Date and sign., repair responsible

Appendix 8: Risk assessment

Risk assessment – Floating collar										Inspection and maintenance	
No.	Element	Unwanted incident	Cause	Probability		Consequence		Risk	Exposure	Measure	Inspection/maintenance
1	Floater tube	Rupture in floater tube	Run into by a boat	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
2	Floater tube	Broken floater tuber	Overload or run into by a boat	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
3	Floater tube	Cut in floater tube	Run into by a boat	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
4	Mooring clamps	Bent mooring lug	Overload or run into by a boat	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
5	Mooring clamps	Broken mooring lug	Overload or run into by a boat	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
6	Mooring clamps	Cracks/breaks in clamp parts	Overload or caused damage	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
7	Mooring clamps, tube clamps	Cracks/breaks in clamp parts	Overload or caused damage	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
8	Clamps	Rupture in railing post.	Overload or caused damage.	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
9	Railing tube	Rupture	Overload or caused damage	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
10	Trusses/chains	Deformation	Overload or caused damage	3	At least once every year	1	Minor escape, 1 to 100 fish	3-1	19 %		A
11	Rods/chains	Rupture	Overload or caused damage	2	At least once every 10 years	4	More than 15000 fish	2-4	50 %	Trusses/chains in the floater collar's perimeter must be inspected often	M
12	Bolt connection	Deformation	Overload or caused damage.	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A
13	Bolt connection	Rupture	Overload or caused damage	2	At least once every 10 years	4	More than 15000 fish	2-4	50 %	Bolt connections must be inspected often	M
14	Floater tube	Loss of buoyancy	Icing	2	At least once every 10 years	1	Minor escape, 1 to 100 fish	2-1	13 %		A

The person who performs inspection and maintenance should have a minimum of 2 years practice on a floating fish farming installation. As a minimum, a monthly check should be performed before and after a period of bad weather.
PS. When it comes to annual checks, it is most practical to perform replacements of parts after each launch. This may be extended to 2 years assuming that the check is made close to the time for the floating collar to be deployed for service again.

Low risk (no actions needed)
Medium risk (actions to be evaluated)
Large risk (unacceptable)



Appendix IV.A
SINTEF Model Tests

Aqualine AS
Dyre Halsesgate 1A
NO-7412 TRONDHEIM
NORWAY**Your ref.**
Martin Søreide**Our ref.**
Henning Braaten**Project No. / File code**
302001288**Date**
2018-01-30

Dear Mr Martin Søreide,

Model Tests of the Midgard System performed at SINTEF

1 Background

SINTEF Ocean, <https://www.sintef.no/ocean/>, performs research and development within maritime, offshore oil and gas, renewable energy, aquaculture, biomarine and marine environmental technology for domestic and international trade and industry.

MARINTEK is from 2017 a part of the new unit SINTEF Ocean through an internal merger in the SINTEF Group. This is a merger of MARINTEK, SINTEF Fisheries and Aquaculture and the Department for Environmental Technology at SINTEF Materials and Chemistry.

The Marine Technology Centre in Trondheim, Norway, consists of two partners: SINTEF Ocean and NTNU (Norway's Technical and Scientific University in Trondheim). The Marine Technology Centre is one of the strongest research and educational institutions within Marine Hydrodynamics and Marine Structures worldwide. Its laboratories built in 1939 (Towing Tank) and 1980 (Ocean Basin) were by the outset considered as national laboratories. The laboratories are central suppliers of technology to the three largest export industries of Norway: offshore oil and gas, fisheries and aquaculture and shipping.

Throughout the years, SINTEF/NTNU has contributed in the development of better ships, and numerous technology challenges within the oil and gas production on the Norwegian continental shelf have been solved through studies in the Ocean Basin and the Towing Tank. This has contributed to an extremely strong and effective specialist community within this field in Norway.

Use of the Towing Tank with carriage for the study of ships' propulsion and seakeeping properties for commercial, educational and research purposes have been a basic part of the activity at SINTEF and NTNU Department of Marine Technology, continuously since 1945.

Offshore oil and gas field developments including floaters and /or subsea production systems have been tested in the Ocean Basin and investigated in parallel with the use of numerical simulation tools. New experiments and analyses of existing offshore installations and of removal operations, complete this picture. SINTEF and NTNU have also during the last 10 – 20 years run a number of research

programs to improve the knowledge of the behaviour of long sea pipelines, vertical flexible risers and similar structures exposed to ocean currents. Novel measuring principles and tools are developed for this purpose.

The Ocean Basin is used for basic as well as applied research on marine structures and operations. A total environmental simulation including wind, waves and current offers a unique possibility for testing of models in realistic conditions. With a depth of 10 meters and a free water surface of 50 x 80 m, the Ocean Basin is an excellent tool for investigation existing and future structures within the marine technology field.

2 Model testing

Hydrodynamic model testing will basically have three different aims:

- To obtain relevant design data to verify performance of actual concepts for ships and other marine structures
- To verify and calibrate theoretical methods and numerical codes
- To obtain a better understanding of physical problems.

Physical models are intended to represent the full-scale system as close as possible at a smaller scale. To be able to determine the proper properties of the model, modelling according to scaling laws that ensure similar behaviour in model as in full scale is applied. When waves are dominating, the Froude's law of scaling is normally used.

3 The Midgard Model Tests

Since 2012 SINTEF Ocean has performed several model test campaigns with the Midgard System.

The first model test campaign was conducted in November 2012. The model tests were performed in a linear scale of 1:16. The objective of the model tests were to study the behaviour of the Midgard System in various wave and current conditions.

The present model test set-up consisted of a cage model with net and mooring system. The diameter of the cage model was equal to 50 m in full scale. The net was purposely built for these model tests, and it had cylindrical shape with vertical side walls and a conical bottom. Different configurations of floater tubes and bottom rings were tested together with different weights in the conical end of the net. The mooring system consisted of a quadratic, horizontal frame mooring system spread out with 4 buoys and 8 mooring lines attached to the seabed. Another 8 horizontal mooring lines facilitated the connection between the frame mooring system and the fish farm.

Forces and accelerations were measured at different connection points between the net, the cage and the mooring lines. For this set-up 6 linear accelerometers were used together with 14 tension rings. Further, the wave elevations and current velocities were measured. Video recordings were taken from both above - and below water cameras.

The model was installed in the middle of the Ocean Basin and the water depth was set equal to 52 m. The mooring lines were attached to the bottom at predefined locations.

A total of 6 different environmental conditions were used for these tests. They consisted of 3 different wave conditions and 2 current speeds, 0.5 m/s and 0.7 m/s. The following wave conditions were calibrated prior to the testing with the wave spectrum formulation according to the JONSWAP formulation as specified by client:

No.	Hs (m)	Tp (s)	Vc (m/s)
1	4.5	8.0	0.0
2	4.5	8.0	0.5
3	4.5	8.0	0.7
4	3.8	13.2	0.7
5	2.5	6.0	0.7
6	2.5	6.0	0.5

The waves were calibrated for a test duration corresponding to 3 hours full scale time.

The full test program consisted of:

- 28 irregular wave tests with current
- 1 irregular wave test without current
- 2 current only tests,

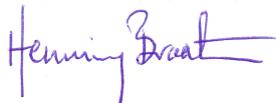
and included parameter variations of rigging of the fish farm, weight changes and elasticity variations.

4 Closing remarks

SINTEF Ocean has developed applied and theoretical expertise in structures and systems for sea-based aquaculture. SINTEF Ocean is a world leader in technological research in the field of exposed aquaculture structures, with structural engineering and hydrodynamics as important subjects.

SINTEF Ocean has several ongoing research programmes on aquaculture. The test methodology used for this project has been developed through decades and is state-of the art.

Yours sincerely,
for SINTEF Ocean AS



Henning Braaten
Research Manager

Appendix IV.B
DNV GL Certification

CERTIFICATION DOCUMENT

Product certification no:
PRONO 073

Certificate issued: 28.01.2015
Revised: 28.11.2016

Aqualine AS

Dyre Halses gate 1A, Portalen, 7042 Trondheim

This certification document applies to serial production of floating collars according to NYTEK regulation and NS 9415. Conditions for the quality system are described in NS-EN 1990, ISO/IEC 17065 and ISO/IEC 17067, scheme type 5.

Floating collars with the same serial number/product name, shall be manufactured in accordance with specifications in the specific product certificate (produktsertifiseringsbevis) for each design, reliability class 2. Approved production procedures shall be followed.

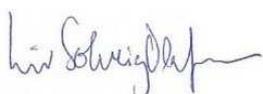
The validity of this certification document requires annual follow-up of the supplier and shall follow the proposed audit plan. The supplier is responsible for delivered collars in the period up to the next audit.

The certification document will be withdrawn if the supplier fails to comply with the provisions on which the validity is based.

DNV GL - Business Assurance is accredited by Norsk Akkreditering as certification body PROD 013 for products regarding the NS 9415, the NYTEK regulation and guidelines for product certification according to requirements in NS-EN ISO/IEC 17065 and NS-EN ISO/IEC 17067.

Place and date:
Bergen 09.12.16

For accredited body:
DNV GL - Business Assurance



Lead auditor



Controller



Certificate:	PRONO 073 Aqualine AS				
Version	Date	Description	Performed by	Internal control by	Date internal control
2	09.12.2016	New certificate template	Liv Solveig Olafsson	Johnny Gravvold	09.12.2016
1	28.01.2015	Certification document issued	Liv Solveig Olafsson	Johnny Gravvold	28.01.2015

Violations of the conditions set out in the certification agreement may render this certificate invalid.

ACCREDITED BODY: DNV GL - Business Assurance Norway AS, Veritasveien 1, P.O. Box 300, 1322 Høvik, Norway. Tel: +47 67 57 99 00. assurance.dnvgl.com

2018-02-12

Confirmation

We hereby confirm that DNV GL Business Assurance Norway AS performs certification of Aqualine AS's floating collars. The DNV GL unit *Technical Aqua Services* is accredited by Norwegian Accreditation for certification of main components used in fish farms. The floating collars are certified according to requirements stated in the Norwegian regulation NYTEK (FOR-2011-08-16-849) and the Norwegian standard NS 9415.

We have certified Aqualine's floating collars since September 2014.

A handwritten signature in blue ink, appearing to read 'Liv Solveig Olafsson'.

Liv Solveig Olafsson
Head of Section
Technical Aqua Services

Accreditation scope for PROD 013

DNV GL Business Assurance Norway AS

P.O.Box 300
1322 Havik

Telephone: +47 55 94 36 00
E-mail: Liv.Solveig.Olafsson@dnvgl.com
Internet: <http://www.dnvgl.com>



The certification body meets the requirements in
NS-EN ISO/IEC 17065

Accreditation was first granted: 01/04/2004
Accreditation requires regular follow-up, and is valid to: 17/03/2019

Accreditation includes:

The administrative / geographical unit:

DNV GL Business Assurance Norway AS
Thormøhlensgate 49 A
5006 Bergen

is accredited for certification of the following products:

Products/Normative doc.	Area of competence / description	Sert system ISO Guide 67	Remarks
Nytek and NS 9415:2009 Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	Nets, float collars, and barges		
Nytek and NS 9415:2009 Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	Construction parts for mooring		
Nytek and NS 9415:2009 Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	Organisations that perform maintenance and repair of nets		
FOR-2017-06-19-941, Forskrift om krav til teknisk standard for landbaserte akvakulturanlegg for fisk	Tanks, pipes, and tubes		NS 9416:2013

Norwegian Accreditation

Skedsmogata 5 PO box 155
N-2000 Lillestrøm Lillestrøm bedriftssenter
N-2001 Lillestrøm

E-mail: akkreditert@akkreditert.no

Telephone: +47 64 84 86 00



Accreditation scope for INSP 006



DNV GL Business Assurance Norway AS

P.O.Box 300
1322 Høvik

Telephone: 55 94 36 00
E-mail: Liv.Solveig.Olafsson@dnvgl.com
Internet: <http://www.dnvgl.com>

The inspection body meets the requirement in
NS-EN ISO/IEC 17020

Accreditation was first granted: 01/04/2004
Accreditation requires regular follow-up, and is valid to: 17/03/2019

Accreditation includes:

The administrative / geographical unit:

DNV GL Business Assurance Norway AS
Thormøhlensgate 49 A
5006 Bergen

Is accredited as Inspection body type A covering following areas:

Field of inspection	Type and Range of Inspection	Normative document/scope	Ramarks/method
Certificate for marine fish farms	new, used, in use, rebuildt, moved	Nytek and NS 9415:2009: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	
Mooring analysis	new, used, in use, rebuildt, moved	Nytek and NS 9415:2009: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	
Main components	used, in use, rebuildt, moved	Nytek and NS 9415:2009: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	
Site surveys	new, used, in use, rebuildt	Nytek and NS 9415:2009: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	

Norwegian Accreditation

Skedsmogata 5
N-2000 Lillestrøm
PO box 155
Lillestrøm bedriftssenter
N-2001 Lillestrøm

E-mail: akkreditert@akkreditert.no

Telephone: +47 64 84 86 00



Appendix IV.C

SINTEF Collaboration with Marine Institute



April 16, 2018

Ms. Joanne Sweeney
Committee Chair
Placentia Bay Aquaculture Committee

Dear Ms. Sweeney;

Please accept the following as a confirmation that the Marine Institute has worked with SINTEF on a number of projects. We have worked in partnership with colleagues both in their Trondheim and Tromso offices. We've actively collaborated in the past, but no active projects at the moment

As a broad multidisciplinary research organization SINTEF has significant expertise in the fields of technology, the natural sciences, medicine and the social sciences.

If you have any further questions, please do not hesitate to contact me at the contact information below.

Sincerely;

A handwritten signature in black ink, appearing to read 'R. J. Shea'.

Dr. Robert Shea
Associate Vice President (Academic and Student Affairs)
Fisheries and Marine Institute

cc: Knut Skeidsvoll, General Manager, Grieg, NL



FISHERIES AND MARINE INSTITUTE OF MEMORIAL UNIVERSITY OF NEWFOUNDLAND

P.O. BOX 4920 | ST. JOHN'S | NL | A1C 5R3 | CANADA | TEL. 709 778 0200 | FAX. 709 778 0346

Appendix IV.D
Accreditation Scope of INSP 036

Accreditation scope for INSP 036

Aqualine AS

Postboks 2200
7412 Trondheim

Telephone: 73809931/73809940
E-mail: jens.aasmul@aqualine.no
Internet: <http://www.aqualine.no>

Copy link



The inspection body meets the requirement in
NS-EN ISO/IEC 17020

Accreditation was first granted: 22/08/2012

Accreditation requires regular follow-up, and is valid to: 18/05/2022

Accreditation includes:

The administrative / geographical unit:

Aqualine AS
Dyre halses gt. 1A
7042 Trondheim

Is accredited as Inspection body type C covering following areas:

Field of inspection	Type and Range of Inspection	Normative document/scope	Ramarks/method
Mooring Analysis	new, used, in use, rebuildt, moved	Nytek and NS 9415:2009: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation and operation	

Appendix IV.E
AON Certification Letter

April 9, 2018

Knut Skeidsvoll, General Manager
Grieg NL
PO Box 457
205 McGettigan Blvd.
Marystown, NL A0e 2M0

Dear Knut:

MARINE CAGE SYSTEMS COVERAGE

Aon is the world's leading insurance broker for Aquaculture and Fish Farm Risks and we are involved in many countries, including Canada in facilitating insurance coverage for land based, vessel and "in water" cage risks.

With respect to Marine Cage Systems, our Underwriters insist that all operators only use and operate fully certified/accredited cage systems that meet internally recognized standards.

We trust that this is understood and if you have any questions, please do not hesitate to call.

Yours very truly,



Robert Duggan, B.Comm.
Senior Marine Account Executive
Senior Vice President/Marine
Aon Risk Solutions

enc
RWD/tl

Grieg NL – Marine Cage Systems – April 2018

Aon Risk Solutions
1969 Upper Water Street, Suite 1001 | Halifax, Nova Scotia B3J 3R7 | Canada
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Aon Reed Stenhouse Inc.

Risk. Reinsurance. Human Resources.

Appendix V

**Code of Containment for the Culture of Salmonids in
Newfoundland and Labrador, March 2014**

DOC-10780

CODE OF CONTAINMENT
FOR THE CULTURE OF SALMONIDS
IN NEWFOUNDLAND AND LABRADOR

March 2014

Aquaculture Branch

Department of Fisheries and Aquaculture

PO Box 679, 58 Hardy Avenue

Grand Falls-Windsor, NL

Canada

A2A 2K2

Tel: (709) 538-3718

E-mail: Normanpenton@gov.nl.ca

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1.0 Background

The Code of Containment is a management strategy for cage culture of salmonids in Newfoundland and Labrador. Implemented in 1999, it originally applied only to the culture of non-local, diploid strains of salmonids and it was affected as a condition of gaining access to the best performing strains of fish while minimizing the risk to wild salmonid populations. The Department of Fisheries and Aquaculture, the Department of Fisheries and Oceans and the salmonid industry have been actively applying the Code to marine cage grow out since that time and have also been stringently reviewing and updating the document to ensure that it continues to meet the intended function.

It is recognized that effective containment of fish is a fundamental aspect of good management practice. For this reason, the Code has been expanded to include all salmonid cage culture in all areas of Newfoundland and Labrador and is a cornerstone of the province's commitment to responsible and sustainable development.

This Code is predicated on a risk management approach and is consistent with the Oslo Resolutions, passed in 1994 by the North Atlantic Salmon Conservation (NASCO) in recognition of the need to minimize the escapement of farmed salmon and to establish design standards for aquaculture cage systems. It also draws heavily on a Code of Containment developed in 1997 by industry stakeholders in Atlantic Canada, Provincial Departments of Fisheries and Aquaculture, The Department of Fisheries and Oceans as well as the netting, cage manufacturing and insurance industries.

This Code of Containment (2012) builds on existing measures including the Industry Code of Practice (1995), the Newfoundland and Labrador Aquaculture Health Management Plan (under review), and the draft Atlantic Code of Containment. Together with these documents, the Code of Containment fashions a management approach that incorporates the necessary and reasonable requirements to ensure the minimization of risks to wild stocks.

2.0 Objectives

The objectives of the Code of Containment are:

- to minimize escapes of farmed salmon (consistent with the NASCO Oslo Resolution);
- to recognize the benefits, including socio-economic, resulting from the development of salmon aquaculture (consistent with the NASCO Oslo Resolution);
- to be forward-looking and seek continual improvement;
- to be comprehensive in terms of both general and site-specific application;
- to be consistent with NASCO priorities concerning the containment of aquaculture salmonids; and,
- to be as stringent and vigorous as containment codes currently existing in other jurisdictions.

3.0 Elements of the Code

The Code of Containment is targeted to the areas of cage culture that have the greatest potential for escapement of fish. Analysis of loss profiles in other jurisdictions has shown that equipment failure and, in particular, net failure, has been the leading cause of farmed salmon escape incidents. While similar research is lacking in Atlantic Canada, anecdotal evidence indicates that, in Newfoundland, ice damage and storm damage to nets are the leading causes of loss. For these reasons, the Code of Containment focuses on the elements of:

Equipment

- appropriate net standards related to design and construction, installation, mesh size, treatment to promote longer life, net strength testing and anti-predator nets;
- appropriate moorings including design and installation;
- appropriate equipment design and practices to address ice security; and,
- predator control measures.

Handling Practices

- appropriate precautions to prevent escape during stages of handling including transfers, counting, grading, harvesting, net changing or cleaning, and towing stocked cages. Handling practices must be consistent with those outlined in the Procedures for Compliance; Appendix 6.

Documentation / Reporting

- regular submission of net testing results; and,
- annual submission of inventory reconciliation including number of fish stocked, mortalities, removals and explanation of discrepancies.

Inspections

- regular inspections of all net, cage and surface mooring components;
- periodic audits of the cage systems as specified in Procedures for Compliance.
- periodic audits of the net testing procedures and results. DFA will arrange for audit of net testing procedures.

Mitigation

- establishment of a recapture plan including the reporting requirement, equipment, personnel, licenses and strategy to execute.

4.0 Responsibilities

The implementation and application of the Code of Containment is a joint commitment of a number of industry stakeholders. Each has clearly defined responsibilities. These are:

Industry

The operators of aquaculture licenses in Newfoundland and Labrador agree:

- to enact measures to the full extent of the Code of Containment to minimize escapes from sea cage culture; and,
- to provide information, maintain equipment standards and to employ practices as outlined.

The Department of Fisheries and Aquaculture

- provides the procedures and protocols required to meet the Code's objectives and guidelines (Appendices 1-5);
- provides the necessary monitoring and enforcement to ensure containment practices and procedures specified in this proposal are followed; and,
- coordinates regular stakeholder review and updates of the Code.

The Department of Fisheries and Oceans

- prepares, and monitors, the recapture component of the Code;
- reviews the inventory reconciliation information required by the Code; and,
- monitors, on a periodic basis, compliance with the practices and procedures of the Code. This may take the form of independent audit, site inspection/visits, or other investigations.

5.0 Compliance and Enforcement

This Code is an integral component of the Newfoundland and Labrador Aquaculture Health Management Plan and as such, it will be a condition of an aquaculture licence to adhere to this Code of Containment. Therefore, the Code of Containment and the Newfoundland and Labrador Aquaculture Health Management Plan will be effected by:

- the inclusion of all practices, procedures and provisions of the Code of Containment, as a condition of licence under section 6 of the Aquaculture Act;
- the provision of monitoring and enforcement by the Departments of Fisheries and Aquaculture and Fisheries and Oceans to ensure practices and procedures are followed;
- the approval of introductions and transfers of being contingent upon implementation, monitoring and enforcement of the provisions of this Code of Containment; and,
- the imposition of sanctions on the aquaculture license, under the Aquaculture Act, which could include restrictions, suspension or cancellation of the aquaculture licence.

**Appendices -
Procedures for Compliance to the Code of Containment**

The following abbreviations will be used throughout the Appendices:

DFA – the Department of Fisheries and Aquaculture (provincial)

DFO – the Department of Fisheries and Oceans (federal)

NTA – the net testing agent.

The Appendices will provide the details of compliance for all areas of the Code of Containment.

It will cover the following aspects:

Appendix 1 – Equipment Standards

A1.1 Nets and Net Testing

A1.2 Cages

A1.3 Mesh Size

A1.4 Moorings

Appendix 2 – Inventory Reconciliation

Appendix 3 – Ice Protection

Appendix 4 – System Inspections

Appendix 5 – Predator Control

Appendix 6 – Handling Practices

Appendix 7 – Measures for the Recapture of Escaped Fish

Appendix 1 – Equipment Standards

A1.1 Nets and Net Testing

Design and Construction

- All nets shall be manufactured by suppliers whose designs meet or exceed standards referenced in this document (Net Testing Breaking Strength Tables 1 – 6)
- Nets shall be designed to perform in the conditions in which they are used (i.e., heavier mesh for sites of stronger current, etc.).

Testing

- nets over three years old and still in use should be tested every 18 months using the four (4) point stress test. This test shall be completed prior to stocking with fish. It is the responsibility of the growers to demonstrate that their nets have been tested.

Responsibility of DFA

- to ensure that growers have submitted annual net inventories and evidence of net testing prior to issuing transfer permits;
- to ensure that growers are performing diver net inspections every 90 days.
- to perform audits on a periodic basis to verify net testing, age of nets and diver net inspections as follows:

Site Net Audit:

DFA will perform on-site inspections of areas of nets in the water that are visible from the surface, recording net tag numbers and net type. Growers will be required to provide proof of net testing upon request and within a given time frame.

Age of Net Audit:

DFA will select a statistically valid number of nets from the net inventory that is listed as less than three years of age. The company shall provide evidence that the net is less than three years

of age and should this not be available, the net shall be tested. The company shall provide the required information within one week from the date of the request.

Net testing Audit: DFA will select a statistically valid number of nets from each net inventory that is listed as having been tested and over 3 years of age. The company shall provide evidence that the net has been tested and should this not be available, the net shall be tested. The company shall provide the required information within one week from the date of the request.

Diver Net Inspections DFA will audit diver net inspection reports twice annually to ensure net inspections are occurring at established intervals.

Responsibility of Industry Members

- To clearly tag all nets with a number;
- To keep an inventory of all nets in use. Information included in the inventory will include net type (i.e., 210/60, 210/80), mesh size, net dimensions and age of net (or date of purchase/manufacture), date of last net test and a list of all nets retired from service during the previous year. Inventories will be submitted in an excel spreadsheet in the format displayed in Appendix 9 on page 46;
- To provide proof of net purchase or manufacturer to verify net age in the event of lost tags, discrepancies or net age audit;
- To provide, prior to fish entry, an inventory of nets in use to DFA and proof that nets have been tested (in the form of a net testing certificate from the NTA). To provide evidence to DFA of nets age upon request for nets less than three years of age. Failure to provide an inventory and evidence of net testing/age of net may result in DFA's refusal to issue transfer permits.
- To inspect nets via diver inspection every 90 days, document the dive and status of the nets, including any holes or repairs and retain copies on site for DFA audit or inspection. If a dive cannot be performed at the specified interval, growers will fill out the dive report

explaining why the dive inspection was not conducted and when the inspection will be completed and retain it for DFA audit. DFA audits/inspections will occur twice annually in conjunction with the Site Surface Inspections in section A4 utilizing Form A.5.

Responsibility of the Net Testing Agent:

- to test nets in accordance with the following procedure:
 - The stress test to be completed with an electronic dynamometer or similar tension scale instrument;
 - For each point tested, the mesh will be tested until it reaches it meets or exceeds the stated breaking strength as outlined in the tables 6.1-6.6. The mesh does not need to be broken if it surpasses established breaking strengths.
 - The four points to be tested on each net are:
 1. the jumpsirt (area between the water line and the top line)
 2. the next 2 meters below the jumpsirt
 3. the side panels
 4. the bottom
 - If components 1 or 2 fail the stress test, the net may be repaired to meet the standard and put back into service. If components 3 or 4 fail the test, the net shall be condemned.
 - Minimum net breaking strengths are listed in Tables 6.1-6.6 (Tables 6.1-6.6 are adapted from the BC *Fisheries Act*, Aquaculture regulations, deposited in April 2002 Appendix 2, Part 1, Section C, II.).
- to record all net tests and retain records of such tests for a period of at least two years. This record will include a form (**Example - Form A.1**) exhibiting the date of the tests, net type, dimension, mesh size, results of the four point test and whether or not the net passed, failed or required repair as per the Code of Containment requirements above.
- to provide the company with a copy of the net testing results which will be signed and dated by the net testing agent.

NET TESTING BREAKING STRENGTH TABLES

Table 1: Net Cage Dimension Classification							
Perimeter	Up to 50m (164 ft.)	> 50m to 60m (197 ft.)	> 60m to 70m (230 ft.)	> 70m to 80m (262 ft.)	> 80m to 90m (295 ft.)	> 90m to 110m (361 ft.)	> 110 m
Depth							
Up to 5m (16 ft.)	A	A	B	C	D	D	E
>5m to 10m (33 ft.)	A	A	B	C	D	D	E
>10m to 15m (49 ft.)	A	B	B	C	D	D	E
>15m to 20m (66 ft.)	B	B	C	D	D	D	E
>20m to 30m (98 ft.)	D	D	D	D	D	E	E
>30m	E	E	E	E	E	E	E

NOTE: A to E establishes net cage dimension classification. Depth is from waterline rope to net cage bottom. Perimeter refers to the line bounding the top of the net cage.

Table 2: Dimension Classification A		
Mesh Size	Minimum Required Mesh Breaking Strength(below surface of water)	Minimum Required Mesh Breaking Strength(jump netting, above surface of water)

< 22 mm (7/8")	20 kg (44 lbs.)	18 kg (41 lbs.)
> 22 mm (7/8") to < 38 mm (1½")	26 kg (58 lbs.)	24 kg (52 lbs.)
38 mm (1½")	31 kg (68 lbs.)	28 kg (62 lbs.)
> 38 mm (1½")	41 kg (90 lbs.)	38 kg (83 lbs.)

Mesh Size	Minimum Required Mesh Breaking Strength(below surface of water)	Minimum Required Mesh Breaking Strength(jump netting, above surface of water)
< 22 mm (7/8")	25 kg (56 lbs.)	24 kg (52 lbs.)
> 22 mm (7/8") to < 38 mm (1½")	31 kg (68 lbs.)	28 kg (62 lbs.)
38 mm (1½")	41 kg (90 lbs.)	38 kg (83 lbs.)
> 38 mm (1½")	46 kg (102 lbs.)	43 kg (94 lbs.)

Mesh Size	Minimum Required Mesh Breaking Strength(below surface of water)	Minimum Required Mesh Breaking Strength(jump netting, above surface of water)
< 38 mm (1½")	36 kg (79 lbs.)	33 kg (73 lbs.)
38 mm (1½")	46 kg (102 lbs.)	43 kg (94 lbs.)
> 38 mm (1½")	51 kg (113 lbs.)	47 kg (104 lbs.)

Table 5: Dimension Classification D		
Mesh Size	Minimum Required Mesh Breaking Strength(below surface of water)	Minimum Required Mesh Breaking Strength(jump netting, above surface of water)
< 38 mm (1½")	41 kg (90 lbs.)	38 kg (83 lbs.)
38 mm (1½")	51 kg (113 lbs.)	47 kg (104 lbs.)
> 38 mm (1½")	62 kg (136 lbs.)	57 kg (125 lbs.)

Table 6: Dimension Class E		
Mesh Size	Minimum Required Mesh Breaking Strength(below surface of water)	Minimum Required Mesh Breaking Strength(jump netting, above surface of water)
< 38 mm (1½")	46 kg (102 lbs.)	43 kg (94 lbs.)
38 mm (1½")	62 kg (136 lbs.)	57 kg (125 lbs.)
> 38 mm (1½")	77 kg (169 lbs.)	71 kg (156 lbs.)

Form A.1 – Four-Point Net Stress Test Inspection

Date

Company

Location of Test

Date of Net Manufacture

Tag Number DFA / Manufacturer	Net Type (mesh size, type, dimensions)	Jumpskirt Breaking strength (lbs.)	Next 2 m below Jumpskirt Breaking strength (lbs.)	Side panels Breaking strength (lbs.)	Bottom Breaking strength (lbs.)	Final Grade (Pass or fail)

Minimum breaking strength is determined from Table 1 (previous page).

Is Net treated with Antifoulant? Yes _____ No _____

Signature (Inspector): _____

Signature (Grower): _____

A1.2 Cages

- All cages shall be of proven design and construction. Plastic Circles and Hercules steel systems are in use worldwide. The design of cages used in Newfoundland and Labrador is based on the plastic circle design that is widely used throughout New Brunswick and British Columbia.
- All new cage system designs shall have a written documentation from the manufacturer outlining construction materials, strength of the system, and information regarding the environment in which the system has been successfully deployed. This information must be available prior to new fish entry to these systems.
- Plastic cages and Hercules systems are design for and used in open coastal waters worldwide.
- All nets are to be secured to the cage collar at every down line with minimum ½” polypropylene rope or rope of equivalent strength as illustrated in the table below. This will be verified by site visits during audits and seasonal inspections (see page 11, 12). Net weights will be hung and weighted in a manner that minimizes chaffing.

Table of various types of ropes and their breaking strengths according to manufacturer specifications.

Diameter(inch)	Polypropylene	Polysteel	Polyex	Polyamide	Dyneema SK75	Sicorsteel
3/16	431					517
1/4	817	750				941
5/16	1030	1282	1213	1346	6700	1193
3/8		1682			10700	
1/2	2203	2318	2641	2999	16400	2591
5/8	3774	4800	4580	5300	27400	4437
13/16	5722	7425	6967	8303		6752
1	8038	10608	9976	12036		9466

A1.3 Mesh Size

- Fish shall be placed in nets of the appropriate industry standard mesh size – i.e., one-third ($\frac{1}{3}$) the size of the widest part of the fish body. Current industry standards are:

1 1/8" stretch mesh	minimum size 50 grams
2 1/4" stretch mesh	minimum size 450 grams

These guidelines exceed the minimum size retained per mesh size as determined in “Determination of the Appropriate Cage Mesh Size for Retention of Salmonid Juveniles” by the Memorial University of Newfoundland’s Marine Institute in March 2000.

A1.4 Moorings

Failure of Moorings systems has not been recognized as a major cause of escapement in Newfoundland and Labrador. Mooring systems in Newfoundland vary from site to site. Some mooring designs are consistent with mooring designs found in Norway for fjord settings, taking into account deep water, rock shorelines and currents associated with fjord hydrography. Other systems are sunken “grid” systems with proven performance in New Brunswick Nova Scotia and here in Newfoundland.

Growers will be required to submit a “Mooring Maintenance/Replacement Plan”, Form A2, annually for each site that will be occupied with fish.

Form A2: Mooring Maintenance/Replacement Plan

Company Name: _____

Site Name: _____

Type of Mooring System (i.e. grid, sunken grid, string): _____

Mooring System Capacity (number of cages designed for): _____

Actual Number of cages moored: _____

Inspection Frequency:

Surface lines/thimbles/shackles/compensators: _____

Submerged lines/thimbles/shackles: _____

Rope/chain mooring lines: _____

Bottom anchors: _____

Describe mooring component inspection procedures and replacement schedule:

If entire system is replaced at one time, when is the next scheduled date for replacement: _____

Site Holder Signature: _____

Appendix 2 – Inventory Monitoring and Reconciliation

- Industry members shall provide to DFA and DFO an annual inventory review, which will indicate numbers of fish introduced, mortalities, removals and escapes;
- The inventory review period will be from January 1 to December 31 annually.
- Industry members shall complete the Inventory Reconciliation by submitting the electronic excel version of Form A.3 early in the new calendar year, at the request of DFA.
- The IR's for trout will be cage based and year class based with each year class appearing on a separate worksheet. All sites used during the year will be listed on the bottom of the worksheet and the current location of cages at the time of IR submission will be indicated.
- The salmon IR's will be cage and site specific, with a separate worksheet used for each site.

Form A.3 – Inventory Reconciliation

Company Name						Aquaculture Site License Number			
Contact Name						Site Location			
Telephone Number						Number of Cages on Site			
Cage Number	Start Fish Numbers	Number of Fish Introduced	Number of Fish Mortalities	Number of Fish Removed/Harvest	Number of Fish Removed/Transfer	Counting Deviation	Number of Fish Escaped	Fish Remaining	
TOTAL									

Note:1. Use additional pages for each site as required.
 2. Number of Fish Removed refers to those fish removed through harvesting.

Appendix 3 – Ice Protection

- Seasonal sites (i.e., a site that must move due to ice conditions) that are currently licensed are protected from moving ice;
- New seasonal sites will be reviewed by DFA/DFO for the potential of damage from moving ice. Any new seasonal sites may require ice booms.

Appendix 4 – System Inspections

- Industry members shall formally monitor and inspect surface components of mooring systems, cages, nets and ropes on each site **once per week** and record the inspection on Form A.4. Inspection forms will be retained for audit and inspection on site by DFA staff.
- Industry members agree to comply with inspections of cages systems and mooring systems at the discretion of DFA or DFO. Audits will be conducted by DFA at a minimum of twice yearly (one audit in the spring, after fish entries; one audit in the fall/early winter) with at least 1 week advance notice to the operator so that site inspection records can be either sent to the DFA or sent to site for examination by DFA inspectors. Inspectors conducting the audits/inspection will use Form A.5 and will examine copies of all site inspections performed by site employees on the site. Copies of the form will be provided to the site owner, DFO and DFA.
- The owner shall repair any identified damage to site equipment immediately.

NL Code of Containment Site Surface Inspection Checklist

Moorings

1. Are all compensator buoys in good condition (no cracks/not sinking)?

a. Yes ___.

b. No ___.

Comments:

2. Are there noticeable signs of wear on the portions of the grid that is visible?

a. Yes ___.

b. No ___.

Comments:

3. Are all shackles screwed tight?

a. Yes ___.

b. No ___.

Comments:

4. Are all thimbles in good condition (no signs or rust/wear)?

a. Yes ___.

b. No ___.

Comments:

Cages:

1. Are there any visible kinks/cracks/wear in the:

a. Cage Collar

i. Yes ___ No ___.

Comments:

- b. Cage support struts**
i. Yes ____ No ____.

Comments:

- c. Jump net rail**
i. Yes ____ No ____.

Comments:

Net:

- 1. Are there any holes in the above water portion of the net/jump net?**

a. Yes ____.

b. No ____.

Comments:

- 2. Is all the net attachment points securely tied to the cage with ½' polypropylene or equivalent rope?**

a. Yes ____.

b. No ____.

Comments:

A.5 Code of Containment Site Audit

Site Name: _____

Company: _____

Record Keeping

Completed

1. Site Surface Inspection Reports. Yes No
2. Dive Inspection Reports. Yes No

Comments: _____

Nets

1. Any visible holes? Yes No
2. All net tags present? Yes No
3. All nets properly attached with 1/2' rope? Yes No

Comments: _____

FOR OFFICE USE ONLY

All nets on site in Compliance. Yes No

All nets tested. Yes No

All nets in inventory. Yes No

Net Inventory submitted. Yes No

Net Manufacture submitted. Yes No

Net Testing Record submitted. Yes No

Comments: _____

Cages

Cage Condition

1. Collar damage? Yes No
2. Support post damage? Yes No
3. Jump rail damage? Yes No
4. Cage tied in to grid properly? Yes No

Comments: _____

Surface Mooring

1. Compensator buoys cracked? Yes No N/A
2. Compensator buoys sinking? Yes No N/A
3. Thimbles exhibiting wear/rust? Yes No N/A
4. Shackles secured tightly? Yes No N/A
5. Grid ropes damaged? Yes No N/A

Comments: _____

Follow up inspection required: Yes No

Reason for follow up: _____

Inspector: _____

Site Representative: _____

Date: _____

Appendix 5 – Predator Control Plans

- Predator Control Plans are incorporated into the License Application for finfish aquaculture sites and must be filled out for each site at the time of licensing. These plans are assessed as part of the aquaculture licence referral process and include review by DFA, DFO, and the Department of Environment and Conservation.

Appendix 6 – Handling Practices

- Industry shall proceed with handling of fish as outlined in Appendix 6.1.
- Industry shall make written request for alternate handling methods prior to handling;
- Industry shall conduct transportation and towing practices as outlined in Appendix 6.2.
- All transfers of fish from hatcheries to sites and from site to site require a Transfer permit and transfer report to DFA outlining numbers transferred, mortalities and any losses. A permit to transfer from DFO is also required for transfer from outside and inside the province.

Appendix 6.1: Best Practices for Handling Fish for the Prevention of Escapes

All instances of fish handling should be undertaken in a manner that both safeguards the health of the fish being handled and minimizes the risk of loss of fish in the process. There are many routine farm practices that require fish handling, such as grading, weight sampling, transportation, well boat applications and harvesting. All staff should be trained in proper handling techniques prior to undertaking any handling-related tasks.

A common mitigative measure to reduce the likelihood of escapes in each handling instance is the use of a **drop net**. The following precautions must be taken prior to using a drop net:

- Nets must be inspected for holes, wear, and any other damage prior to use. If damage is detected, the net should be mended immediately, or suspended from use until such a time as it is repaired.
- Nets must be of sufficient size to cover entire work area
- Mesh size should be small enough to contain the smallest fish being handled

Grading

The requirement to grade fish is determined by a company's production strategy and scale of operation.

- The attending aquaculture veterinarian must be consulted regarding fasting requirements for this activity. Depending on the health status of the fish, the veterinarian may offer additional fish health advice.
- An aluminum or stainless steel grading table is utilized which sorts fish by size into different sea cages through directional troughs.
- A drop net must be used.
- If fish are being pumped from a cage to a vessel (and/or vice-versa), a drop net must cover the entire area under the pump pipe. The pipe should be double walled, or a net must be wrapped around the entire length of the pipe in case of breach.

Weight sampling

Weight sampling is undertaken to determine fish growth and to facilitate adjustments to the feeding plan and inventory calculations.

- Fish must be collected using a dip net.
- A drop net must be used.

Sea Lice counts

The requirement to count sea lice is determined by the attending aquaculture veterinarian and the companies' fish health management strategies.

- Fish must be collected using a dip net.
- A drop net must be used.

Transportation

Transporting fish, whether by sea or land, should be completed in a way that ensures the health

and safety of the fish and limits the possibility of escapes.

- Continual monitoring of the fish during transport must be conducted. This will include, but is not limited to; monitoring dissolved gases (oxygen, carbon dioxide etc...), water temperature and fish behaviour. The attending veterinarian and the NL DFA – Aquatic Animal Health Division must be contacted if concerns or mortality are noted.
- Transporting fish cages must follow the Best Practices for Towing of Stocked Cages Appendix 6.2.
- If fish are being pumped from vessel to fish boxes or cages (or vice-versa), a drop net must cover the entire area under the pump pipe. The pipe should be double walled, or a net must be wrapped around the entire length of the pipe in case of breach.

Well Boat Treatments

Well boats can be used for the purpose of bath chemotherapeutant treatments. This will occur under the guidance of a licensed aquaculture veterinarian and requires a veterinary prescription.

- Fish that are being pumped from a cage to a vessel (and/or vice-versa) require that a drop net cover the entire area under the pump pipe. The pipe should be double walled, or a net must be wrapped around the entire length of the pipe in case of breach.

Harvesting

Harvesting of fish can occur on site or cages may be towed to another location, such as a wharf, prior to harvesting.

- Dip nets, brailer nets or fish pumps must be used when harvesting fish
- A drop net must be deployed during all harvesting activity where there is risk of fish falling or jumping off of grading or slaughter tables.

Appendix 6.2: Best Practices for Towing Stocked Cages

Towing of cages from site to site must be undertaken in a manner that safeguards the health of the fish and that minimizes the risk of loss of fish in the process.

The towing of cages requires carefully planned logistics and the development of contingency plans. Each individual move will be governed by numerous factors. There are several issues and practices common to most cage towing exercises. These include:

- Each tow must be approved by the Department of Fisheries and Aquaculture staff to ensure compliance with Bay Management Initiatives. The Aquatic Animal Health Division must be notified of fish movements to allow trace-back and trace-forward analysis, periodic audits and biosecurity requirements.
- Discussions must be conducted with DFA Aquatic Animal Health Division or the attending veterinarian to ensure health and safety of fish during planned towing exercises. The veterinarian will advise if it is necessary for fish to be taken off feed for the move, advise on the route of the tow and mitigation strategies to minimize stress on the fish. This advice will be dependent on a number of factors including, but not limited to; the health status of the stock, water temperature, duration of tow, species and size of fish.
- The towing route must be carefully considered prior to any movement. Considerations include, but are not limited to; duration of the tow, fish health status of the fish, the species and age of the fish, water temperature, water quality and water depth. The towing route must consider the location of other fish farms, processing plants and fishing activities. Towing routes that maintain a minimum 5 Km distance from these activities are preferred.
- Efforts must be made to cooperate with local fishers to ensure cage towing will not interfere with traditional fishing activities.
- Each net must be inspected by divers or underwater cameras prior to towing to ensure structural integrity. A second inspection shall be conducted immediately following the tow, or as soon as is practicable.
- Each tow shall be undertaken by a minimum of two vessels, with one serving as a backup.
- Close attention shall be paid to securing tow lines to the towing vessel. Care must be taken not to secure the line too far aft, as this will restrict the towing vessel's ability to steer.
- The towing vessel must carry extra rope and a small roundabout (12' to 16').
- The tow line must be long enough to allow the wake of the towing vessel to dissipate before it reaches the cages in tow.
- Attention must be paid to tides, current, and wind forecasts, as some tows will consume 24 hours or more. Short tows in Bay d'Espoir commonly take 4-6 hours.
- The nets of cages to be towed are to be shortened to reduce drag and to prevent "bagging" of the net while in tow.
- The nets must be clean and free from fouling to decrease drag, stress on the nets and increase water flow within the cage.

- A heavier set of net weights (anchors) should be used to prevent “bagging”.
- Each towing vessel must have significant power to advance the cages in tow at an adequate speed to accomplish the tow.
- The speed of the tow, including calculation for current velocity, must not exceed the maximum speed of the slowest caged fish in tow. Preferable tows will occur “with the tide”. Towed cages must be checked frequently during a tow to ensure that the fish are keeping up with the speed of the tow.
- Any live fish or mammal that becomes entangled in lines or netting during transport must be immediately released to waters outside the aquaculture facility; dead incidental catches must be disposed of in the same manner as farm mortalities.

Appendix 7 – Measures for the Recapture of Escaped Fish

Introduction

In 1999, the Minister of Fisheries and Oceans authorized the use of all-female diploid rainbow trout and Northwest Atlantic salmon strains for marine cage culture subject to the adoption of a Code of Containment that described measures to prevent and respond to escape incidents. While the focus of the Code is on measures intended to minimize the potential for escape incidents, it is acknowledged that escape incidents may periodically occur. In the event of an escape incident, consideration of recapture of escaped salmonids is a requirement under the Code.

The objectives of recapture efforts are to provide an opportunity for farms to recover their losses, to reduce the amounts of escaped salmonids in nature, and to contribute to minimizing the potential for interactions between wild and farmed fish. Recapture strategies may include directed recapture fishing by stock owners and use of other commercial, recreational, or aboriginal fisheries. The success of recapture strategies implemented following escape incidents is dependent upon escaped fish behavior and biological and environmental factors affecting catchability, all of which are highly variable.

Authorization of recapture is at the discretion or direction of the Department of Fisheries and Oceans in consultation with the farm owner and other stakeholders, as needed. It will consider the life history stage of the escaped fish, the time of year, incident-specific factors, and conservation objectives for wild fish populations. Consequently, not all escape incidents will trigger recapture efforts even though all incidents will be reported.

1. Purpose

This document has been prepared to provide salmonid aquaculturists with a clear and concise statement of their obligations and the Department of Fisheries and Oceans' policy respecting the recapture of escaped farmed Arctic char, Atlantic salmon, and steelhead trout in Newfoundland and Labrador.

2. Eligibility for Recapture License

1. The recapture license will be issued to the Aquaculture Site License Holder or to a designated third party that is suitably equipped to recapture escapees on behalf of the License Holder(s).
2. To be considered for a recapture license, Aquaculture Site License Holders will be required to have a recapture plan and have personnel trained in the deployment and retrieval of fishing gear.

3. Activation/ Trigger

In the event of an escape incident where it is reasonable to believe that there may have been an estimated loss of 100 or more fish from any one cage, the incident is deemed to constitute a significant escapement and the license holder is required to commence discussions with DFO within 24 hours of the incident to determine if recapture efforts should be initiated.

4. Reporting Requirements

1. Immediately upon discovery of a significant escapement or when it is reasonable to suspect that any escape incident has occurred, the site license holder must report the incident verbally or via email to DFO by contacting Aquaculture Management at 772-0183 or 772-3265 and to DFA by contacting the Regional Aquaculture Manager at 538-3725.
2. License holders are required to file a written report (**Annex 1**) within 72 hours of the escape incident to the Director, Aquaculture Management, Fisheries Management Branch, Fisheries and Oceans Canada, P.O. Box 5667, St. John's, NF, A1C 5X1. Reports will be forwarded by DFO to DFA.
3. License holders are required to maintain records of all recapture fishing activity in accordance with conditions of licence in the form of a logbook (**Annex 2**). Normally, catch and effort will be reported daily or weekly to DFO or in accordance with licence conditions to Aquaculture Management, Fisheries Management Branch, Fisheries and Oceans Canada, P.O. Box 5667, St. John's, NF, A1C 5X1.

5. Recapture Gear

1. Recapture activity will be permitted using gillnets and seines with mesh sizes ranging from a minimum of 38mm to a maximum of 127mm.
2. Recapture activity will be permitted using traps (maximum mesh size 35mm).
3. Recapture activity will be permitted using angling gear.
4. The “Minimum Recommended Gear” guideline (**Schedule 1**) is intended to provide an initial response capacity to escape incidents. If necessary, it is expected that growers will collaborate, by sharing recapture gear, or enter into arrangements with commercial fish harvesters to ensure that adequate recapture efforts are implemented.

6. Recapture Licences and Conditions

1. Licence conditions may specify the type, size and quantity of fishing gear and equipment permitted to be used; the manner in which it is permitted to be used; the specific locations at which fishing gear is permitted; the period during which fishing is permitted to be carried out; and information that the licence holder shall report.
2. For the purposes and protection of fish, the conditions of a licence may be amended.
3. Biological samples from catches may be required and the number and nature of samples will be determined by DFO.

7. Incidental Catch or Bycatch

Except where the retention of an incidental catch is expressly authorized, all non-farm origin fish captured must be released immediately at the place they were caught and where it is alive, in a manner that causes it the least harm.

8. Recapture Plan

Aquaculture Site Licence Holders are required to complete and submit a “Recapture Plan and License Application” (**Annex 3**) on a site-by-site, year-class, or single-year or multiple-year production plan basis describing individuals designated to conduct recapture activity, amount and location of recapture fishing gear, aquaculture sites covered under the plan, and disposal procedures for recaptured fish.

SCHEDULE 1
MINIMUM RECOMMENDED GEAR

It is suggested that each grower should have access to a minimum of two sets of gear and a set of gear for every two active aquaculture sites.

A “set of gear” is defined as four 50-fathom-long gillnets, one of each mesh size: 3½”, 4”, 4 ½” and 5” (89mm, 102mm, 114mm, and 127mm, respectively).

# OF AQUACULTURE SITES	# OF “SETS” REQUIRED
1	2
2	2
3	2
4	2
5	3
6	3
7	4
8	4
9	5
10	5
11	6
12	6
13	7
14	7
15	8

ANNEX 1
ESCAPEMENT REPORT

This form or template of information is to be completed and faxed or emailed to Aquaculture Management, Fisheries Management Branch, Department of Fisheries and Oceans (fax #: 772-3628) within 72 hours of an escapement incident

Site License #: _____
Location: _____
Name of Company: _____
Contact Name: _____
Telephone: _____
E-mail: _____

Details of the Escapement

Date/Time of Occurrence: _____
Cause of Escapement: _____

Species /Strain of Fish Escaped: _____
Number of Cages Subject to Loss: _____
Estimated Number of Fish Escaped: _____
Average Size of Fish Escaped: _____
Amount of Time from Escape Event to Deployment of Recapture Gear: _____
Additional Notes/Comments:

10. ANNEX 3

11. RECAPTURE PLAN & LICENSE APPLICATION

I. Identification

12. Company:
 13.
 14. Licensed Aquaculture Sites (License # and Location):
 15.
 16. Species on Site(s):
-

II. Recapture Provider

Who Will Be Providing Recapture Services:

III. Response Details (not applicable to those relying exclusively on a 3rd party for recapture)

Recapture Gear (e.g # of gillnets by mesh size, length, depth, etc.):

Individuals Designated To Conduct Recapture Activity:

- | | |
|----------|----------|
| 1. _____ | 2. _____ |
| 3. _____ | 4. _____ |
| 5. _____ | 6. _____ |
-

IV. Disposal Plan

What Is Your Plan for Disposing of Recaptured Fish:

V. Signature

Applicant: _____

Date: _____

COMPLETED PLANS ARE TO BE SUBMITTED TO:

Aquaculture Management
 Fisheries Management Branch
 Fisheries and Oceans Canada
 PO Box 5667,
 St. John's, NF, A1C 5X1

APPENDIX 8 - Post Escape/Incident Review

Escapes and incidents that could have led to an escape (i.e. hole in net without escape, cage collapse resulting mortality, but no escape) are regularly reported to DFA and DFO. All escapes or incidents with potential for escape will be reviewed by DFA and DFO to determine if the incident(s) require new amendments to the code or the adoption of other management strategies to prevent such incidents from happening again.

Growers will submit the attached **Escapement/Incident Report** once the farm site involved has been secured and any associated recapture efforts have been concluded. The Department of Fisheries and Aquaculture and Fisheries and Oceans Canada will conduct a review of the escape/incident as follows:

- The **Escapement/Incident Report** will be reviewed to determine:
 - Cause of the escape/incident.
 - Whether the escape/incident was preventable.
 - Level of remedial actions taken by the grower,
 - Success of recapture effort (if any)
 - Appropriateness of proposed future preventative measures for that type of incident.
- History of site and grower with regards to escapes and incidents.
- Assessment of site documentation required by the Code of Containment (Weekly Site Surface Inspection/Net Inspection).
- Review of the previous Code of Containment Inspection undertaken by DFA.

Upon completion of the review the following steps will be undertaken:

- 1) If it is determined that the grower has performed its due diligence with regards to escape prevention, mitigation and response and that the incident was not preventable, then no further action is required.
- 2) If it is determined that the growers proposed escape/incident prevention measures are inadequate then the grower will be required to resubmit new prevention measures for reevaluation.

- 3) If it is determined that the grower has not demonstrated due diligence with regards to the Code or has a history of similar escapes, the Department may take action that may include, but not be limited to, suspension of license or other directives pertaining to securing of site or escape prevention.
- 4) If it is determined that escapes of a similar nature have occurred industry- wide then DFA/DFO will propose changes to the Code of Containment to address the specific area of concern and present it to the Code of Containment Liaison Committee for inclusion into the Code.

All escape incidents or incidents that may have led to escape will be identified in the Annual Compliance report, including what was done to prevent future escapes of a similar nature.

Escapement/Incident Report

Incident description: _____

Date of Incident: _____

Identified Causes of the incident: _____

Escape Response Efforts: _____

Date	Gear Deployed	Numbers Captured
------	---------------	------------------

Follow-up Measures to prevent Future Escapes: _____

Appendix VI
Plastic Pipe Institute –
Recommended Minimum Training Guidelines

**Recommended Minimum Training Guidelines
for PE Pipe Butt Fusion Joining Operators
for Municipal and Industrial Projects
TN-42 / March 2013**

Foreword

This technical note was developed and published with the technical help and financial support of the members of the PPI (Plastics Pipe Institute, Inc). The members have shown their interest in quality products by assisting independent standards-making and user organizations in the development of standards, and also by developing reports on an industry-wide basis to help engineers, code officials, specifying groups, and users.

This technical note has been prepared by PPI as a service to the industry. The information in this note is offered in good faith and believed to be accurate at the time of its preparation, but is offered “as is” without any express or implied warranty including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Any reference to or testing of a particular proprietary product should not be construed as an endorsement by PPI, which does not endorse the proprietary products or processes of any manufacturer. The information in this report is offered for consideration by industry members in fulfilling their own compliance responsibilities. PPI assumes no responsibility for compliance with applicable laws and regulations.

PPI intends to revise this note from time to time, in response to comments and suggestions from users of this note. Please send suggestions of improvements to the address below. Information on other publications can be obtained by contacting PPI directly or visiting the web site.

The Plastics Pipe Institute, Inc.

www.plasticpipe.org

March 2013

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PURPOSE

The purpose of this document is to provide a general outline of PPI's recommended minimum guidelines for training an operator in properly and safely making good quality butt- fusion joints in PE pipe systems. This training guide is intended to recommend a consistent minimum level of fusion operator proficiency; certain installations may require additional operator training and proficiency.

SCOPE

Butt fusion joining of PE pipe is a relatively simple, forgiving, and dependable process. However, as with any kind of pipe installation, proper procedures and diligence must always be used to consistently make satisfactory joints. Fusion machine operators should demonstrate an aptitude for using mechanical equipment and be generally familiar with laying pipe. They should have a demonstrated ability to follow procedures and be conscientious in their work. The amount of time it takes to provide the specified training can vary greatly and depends on the number of individuals being trained as well as their aptitude and willingness to follow directions. However, participants shall not be considered "trained" until they have demonstrated proficiency on at least two test joints made under circumstances and field conditions representative or similar to those of the project.

PE Pipe Sizes and SDR/DR

PE pipe for use in industrial and municipal applications is produced in accordance with applicable industry standards (ASTM, AWWA, API). In AWWA, the pipe outside diameters (ODs) conform to the OD dimensions of iron pipe IPS, or to equivalent OD for DI pipe (DIOD). In general, pipes are manufactured and measured based on OD (outside diameter) and wall thickness. The ratio of outside diameter to minimum wall thickness defines the pipe's SDR (Standard Dimension Ratio) or DR (Dimension Ratio) number. These numbers also define the pipes pressure rating at 80°F (27°C) in AWWA standards. And, because of the importance of the information these numbers convey, they are required to be included in the pipe markings specified by the applicable industry standard. These standards require that all pipes be clearly marked at specified intervals with the following information:

- Name or trademark of the manufacturer
- Production code number to identify location and date of manufacture.
- Nominal pipe size
- IPS or DIPS
- SDR or DR number, or pressure rating, or both

- The applicable industry standard(s) with which the pipe complies e.g. ASTM, AWWA, API or a combination of those specifications to which the pipe may have been manufactured, (e.g. ASTM F714 / AWWA C-906).
- Use the Pipe Size and SDR/DR to determine the proper fusion pressures applicable for the fusion machine and product being joined. In the event this information is not immediately available the user is advised to consult with either the fusion equipment or pipe supplier.

Links to PPI and the major equipment suppliers are listed as follows:

- Plastics Pipe Institute www.plasticpipe.org
- Connectra Fusion Equipment <http://www.connectrafusion.com/fusion-calculator.php>
- McElroy Manufacturing Fusion Equipment <http://www.mcelroy.com/fusion/calculate.htm>
- RITMO America <http://www.ritmoamerica.com>

MACHINE QUALIFICATION

The selected fusion equipment shall be capable of meeting all parameters of the job. The equipment shall have jaws or reducing inserts designed to properly hold the size of the pipes being fused, and it shall have enough hydraulic force to reach the required fusion pressure during all fusion conditions. The fusion operator shall be thoroughly familiar with and trained on the equipment being used. Such training shall include at least the following:

- 1) Safety
- 2) Operator's manual & checklist
- 3) Basic maintenance and troubleshooting
- 4) External power requirements
- 5) Features
- 6) Components and how they operate
- 7) Hydraulic operation (if applicable)
- 8) Determining required fusion pressure and how to set on machine
- 9) Heater operation and temperature requirements and adjustment
- 10) Data logging device (if applicable)

Job Set-up Guidelines

Weather Guidelines: Successful butt fusions can be accomplished in a broad range of weather temperatures. Pipe ends and the fusion equipment must be dry and sheltered from rain and wind. The limitations are driven by products and the equipment being used.

While PE pipe has very good impact resistance even in sub-freezing conditions; nonetheless its impact strength is reduced as temperatures drop into these ranges. Therefore, avoid dropping pipe in sub-freezing conditions. Also, keep in mind that butt fusion, when temperatures are below -4°F (-20°C), generally requires special provisions such as portable shelters or trailers or other suitable protective measures with auxiliary heating. Here are some general guidelines to address different weather conditions:

Cold Temperatures, Down to 32°F (0° C): When butt fusing PE pipe under these conditions, it is recommended that a temporary wind barrier be set up around the operator and fusion equipment. It is also recommended that the pipe ends be closed off by use of end caps or other means to prevent the flow of cold air. These measures will help greatly to reduce the heat loss in the heater plate and provide for a more uniform heating cycle and improved operator efficiency.

Cold Ambient Temperatures Below 32°F (0° C): In addition to the above, the following preparations should be undertaken before fusing pipes. Pipe ends should be pre-heated using a heating blanket or warm air devices to elevate the pipe temperature to improve the heat cycle starting condition. With pipe mounted in the fusion machine, an alternate method of pre-heating is to position the pipe ends within ¼ to ½ inch of the heater plate face to allow the pipe ends to warm for 30 seconds to 2 minutes, depending on the pipe size and wall thickness. Before starting pipe fusion, the operator needs to ensure that the ID of the pipe is clear of moisture possibly due to frost that is being melted during the warming operations.

Notice: The use of direct application open flame devices, such as torches, for heating PE pipe is prohibited due to the lack of adequate heating control and the possibility of oxidative damage to the pipe ends and even ignition of the pipe. The warming temperature should not be continuous nor exceed 120°F (49°C).

Warm (Hot) Environment, 32° F (0°C) to 120° F(49°C): . Elevated temperature conditions can be mitigated by shading of the operator and the equipment where applicable.

Wind: Exposure of the fusion heater plate and pipe to wind can result in unacceptable temperature variations during butt fusion and possible joint contamination. When unfavorable wind conditions exist, the provision of a suitable shelter is required to

protect the pipe and the fusion heater plate to ensure more consistent work performance. Unfavorable wind conditions can also flow through the pipe bore and cause unacceptable temperature variations during the fusion process, therefore open pipe ends may require plugs or covers to prevent this condition.

Additional Considerations:

- PE pipe and fittings will expand and contract with changes in temperature so in such an event be prepared to make necessary adjustments.
- Where pipes are to be clamped in the fusion machine, make sure pipe, fitting and clamp surfaces are dry, clean and free of ice, frost, snow, dirt and other contamination.
- When butt fusion is done in cold weather, DO NOT INCREASE THE HEATING TOOL SURFACE TEMPERATURE to attempt to compensate. THE REQUIRED SURFACE TEMPERATURE MUST BE WITHIN THE SPECIFIED RANGE BETWEEN 400-450°F (204-232°C) with 425°F (218°C) being the target temperature. Some butt fusion equipment is operated hydraulically through the use of motor and hydraulic oils. When operating such hydraulically assisted equipment at ambient temperature extremes, read operators manuals to make necessary viscosity adjustments to aide in the equipment's performance. The same holds true for generators supporting the butt fusion equipment.
- In cold conditions, it will take longer to develop an indication of melt around the pipe circumference at fusion pressure and longer to develop the final bead size in the heat soak cycle.
- DO NOT apply "fusion pressure" during the heat soak cycle. When proper melt has been obtained, the pipe and heater should be separated in a rapid, snap-like motion on manually operated equipment. The melted surfaces should be inspected (looking for a smooth melted surface) then be joined immediately in one smooth motion so as to minimize cooling of the melted pipe ends.
- See Annex A1 Cold Weather Procedures in ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings for additional information and guidance.

Pipe Handling Guidance: The jobsite pipe storage area should be relatively level and smooth. It should be large enough to allow for safe movement of the pipe and pipe handling equipment. The optimum situation is to have the pipe stored in close proximity to where the fusion equipment will be used for joining. The pipe should be placed on wooden beams or other type supports to keep it out of the dirt, mud etc. Where ground is level, the pipe or bundles of pipe can be stacked as high as about 6 ft. but not more. Where the ground is not very level, pipe should not be stacked in bundles but should be placed individually next to one another. Likewise, coils of pipe should not be stacked on each other but should be placed individually on protective supports on the ground. Coils should be stored in such a manner as to prevent any possibility of rolling or falling over.

DANGER: Coils, bundles, and even individual lengths of pipe are very heavy and by falling or rolling over can result in property damage, serious injury or even death.

For lifting pipe whether it be single pieces, coils or bundles it is extremely important to use only properly weight rated fabric slings capable of handling the load. DO NOT use wire rope or chains to lift or move pipe, they will damage it.

Special care should be taken when cutting tie bands on coils or on bundled pipe. As mentioned earlier, falling, rolling, or springing pipe can be extremely dangerous. First, cut only the bands on the outside and work carefully to extract the pipe pieces as needed.

Pipe Stands and Supports:

When butt fusing lengths of pipe it is necessary that pipe support stands be used. These pipe support stands work best when they are positioned on either side of the fusion machine approximately 20' from the pipe ends. Adjust the height of the stands so that the pipes are level; this will help to reduce pipe drag. The more stands that are used the more freely the pipe(s) move into and through fusion machine.

Other devices such as carts, racks etc. can be used to aide in supporting and feeding pipe into and through fusion units.

Do's and Don'ts in Pipe Handling:

DO's

- Make sure the pipe is secure and balanced prior to moving
- Store pipe on a level surface prior to use if possible
- Read and adhere to all published safety procedures on the subject of PE pipe handling
- When installing PE pipe do take into consideration that in locations that may experience large temperature swings between day and night, exposed pipe that is not restrained will change in length due to expansion and or contraction. For the condition of a drop in temperature, the pipe contraction could affect any lateral connections installed in the line; if the line contains bell and spigot or mechanical joints with insufficient pull-out resistance, then there exists the potential for joint separation. Exposed pipe that is anchored has a different response to the condition of a drop in temperature; namely, the generation of longitudinal loads that result in increased tensile stress. Temperature increases have the opposite and other effects. Therefore, it is very important that the effects of thermal change be taken into account when installing pipe. For additional information on this subject the reader is referred to the PPI PE Handbook, Chapter 6 - Section 4. Once the pipe is buried and

compacted in the ditch, (not free floating or unrestrained) temperature change has very little effect on the pipe.

- Before pulling pipe, do check for its maximum allowable pulling load. The safe pulling load depends on the pipe's OD its wall thickness and material grade. For the recommended safe values the user is referred to the Tables on this subject in Chapter 12 in the PPI PE Handbook.

DON'TS

- While PE pipe is an extremely tough material it can be scratched or gouged, therefore, it should not be pulled or dragged over sharp objects. Pipe is generally not acceptable for installation if it contains damage that exceeds about 10% of the minimum wall thickness of the pipe designed for the application. For more details on this subject, the reader is referred to the PPI's PE Handbook, Chapter 2, section entitled 'Damage Inspections' or consult with the pipe manufacturer.
- Ignore recommended handling and installation procedures
- Bury the pipe with large sharp rocks, tree roots or other rigid objects against the surface of the pipe
- Kink the pipe during handling or installation.
- Perform rough handling of a fusion joint for at least 30 minutes after it has come out of the fusion machine. Additional time may be required for pipes with wall thicknesses greater than 2 inches, especially if the prevailing ambient temperature is above 90°F.
- Stick the forklift forks into the side of the pipe.
- Stand under or anywhere close to the pipe while it is being unloaded from a truck
- Fuse pipe in a dust storm without a shelter (Dust can contaminate the fusion joint)⁽¹⁾
- Fuse pipe in a rain storm without a shelter (Water can contaminate the fusion joint)⁽¹⁾

⁽¹⁾ For additional information on this topic please refer to the discussion under the Job Set-up Guidelines Section

Safety

- PE Pipe is an inert substance that poses no known health risk. Polyethylene (PE) is used to wrap the food you eat and PE pipe is used extensively for transporting potable water, so touching the pipe is completely safe.
- Always wear personal safety gear including hard hat, steel toed shoes and safety glasses.
- Do not stand in the path of the pipe being loaded or moved. Miss-handled, rolling or falling pipe can result in serious injury or death.
- Before starting or performing any work with the fusion equipment, it is very important that the operator carefully read and accept the equipment manufacturer's instructions on safety and operation that are published in the Manufacturer's Owners Manual. This is emphasized particularly because of the fact that while most heat fusion equipment is electrically powered, it is not explosion proof. Therefore, special attention is needed when performing fusions in an atmosphere that may be volatile, such as when gas or coal / grain dust may be present. Also, handling of the heating irons deserves special care insofar as they are very hot, greater than 400°F (204°C).
- Before unloading, reloading or moving pipe or equipment, carefully read and adhere to all published procedures and safety related documents. (PPI's PE Pipe Handbook, PPI's Materials Handling Guide publication and the pipe manufacturers literature,)
- Keep hands out of harm's way when loading pipe into, or removing it from the fusion machine. Likewise, for working with any other related pipe assembly or installation equipment, carefully follow all established safety procedures

Butt Fusion – A Six Step Process

This section outlines the Butt Fusion Procedure, per ASTM F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings. See PPI TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe for the testing completed to verify the use of the procedure in ASTM F2620.

Please read carefully and fully understand equipment set-up and all six steps before beginning the fusion process. Also, before operating the fusion equipment, carefully read and understand the equipment manufacturer's published instructions on safety and

operation and refer also to the highlights listed under the preceding Safety Section of this document.

Butt Fusion Machine Set-up

The operator should be familiar with these concepts before starting the 6-step Butt Fusion Procedure.

Heating Pressure: Carriage pressure during the heating process is a two step process. Initial contact is made at the pre-set fusion gauge pressure. After a melt bead is observed all around the pipe, this pressure should be lowered to the drag pressure (called “soak pressure”) for the remainder of the heat cycle. During this time the hydraulic valve system should “lock” the carriage into position where it can neither move forward nor backward.

Facing Pressure: With pipe ends clamped into the fusion unit, apply just enough pressure to bring the two pipes into contact with the rotating facer, being careful not to slam into and possibly bog down or jam the facer unit.

Fusing Pressure: Take the drag pressure and add it to the calculated fusion pressure to obtain the fusion gauge pressure; see ASTM F 2620 and/or pipe distributor.

Drag Pressure: Drag Pressure is something that needs to be considered when butt fusing PE pipes and or fittings together. Drag is the amount of gauge pressure needed to overcome the frictional resistance of the hydraulic unit itself (called “static drag,” and usually amounts to around 30-50 psi) combined with the amount of pressure needed to overcome the resistance of the pipe that is being pulled into the facer and heater (called “dynamic drag”). This amount can vary from very little to an amount that could potentially exceed the hydraulic capacity of the fusion unit (e.g., if fusing a long spool of pipe that is not well supported). The amount of drag pressure in PSI needs to be added to the theoretical fusion pressure to get the final calculated fusion gauge pressure. After facing the pipes, move the carriage so that the pipe ends are approximately 2” apart. To determine the drag pressure, adjust the pressure on the carriage so that it is not moving at all. Gradually increase the pressure until the carriage barely moves, observing the pressure gauge. Repeat if necessary. The pressure being indicated to just move the carriage is the drag pressure. (If fusion conditions change, this procedure must be repeated.)

Butt Fusion Procedure

NOTE: When using hydraulic fusion equipment, correct operation of hydraulic controls for carriage movement and pressure regulator selection is essential to produce quality

butt fusions. Improper hydraulic control operation can seriously compromise butt fusion joint quality.

STEP 1 - Securing the Pipe SECURE THE PIPE IN THE JAW CLAMPS OF THE FUSION MACHINE TO ENSURE CORRECT ALIGNMENT. THERE SHOULD BE NO SLIPPAGE OR UNINTENDED MOVEMENT OTHERWISE CORRECT FACING WILL NOT BE ACHIEVED.

a) **Adjust, Align and Secure.**

- i) Adjust and align the pipe ends to minimize any parallel misalignment (high / low) or angular misalignment when the pipe ends are brought together.
- ii) Adequately tighten the clamps so as to prevent any unintended movement or slippage of the pipe when the pipe ends are brought together.
- iii) On a four-jaw fusion machine, first clamp the outer-jaws to secure the pipes, then the inner-jaws to allow for high / low adjustment during "Step 2 Facing the Pipe Ends".

b) **Clean, Clean and Clean**

- i) Clean the exposed pipe ends approximately three inches back along the pipe's inner and outer walls.
- ii) Clean to remove any surface contaminants. See ASTM F2620 Appendix X1.7.1 for additional guidance.
- iii) Always use a clean, dry cotton cloth when cleaning pipe ends to be fused.
- iv) Never use a synthetic cleaning cloth; a lint-free cotton cloth is required.
- v) All fusion surfaces must be completely clean and dry to achieve a proper fusion.

c) **Allow for the pipe ends to extend through the jaw clamps to permit complete facing.**

- i) Assure that pipes are cut as square as possible so as not to damage facer pivot arms.

STEP 2 - Facing the Pipe Ends TO PREPARE FOR HEATING IN STEP 4, THE PIPE ENDS MUST BE PREPARED BY FACING OFF MATERIALS TO PROVIDE SMOOTH, PARALLEL AND CLEAN MATING SURFACES.

- a) Position the facing tool into the fusion machine between the secure and aligned pipe ends.
- b) Activate the facing tool.
- c) Bring the pipe ends into contact with the rotating facing tool.
- i. With manual machines use only minimal pressure to initiate and maintain the cutting process between the pipe ends and the rotating surface of the facing tool. Hydraulic machines should be set to “facing pressure”.

Note - Excessive pressure may create too much of a load on the facer motor causing the facing tool to “bog down”, and potentially damaging both the facing tool and the fusion equipment.

- ii. The correct facing process will have complete ribbons of polyethylene that are shaved from the pipe ends.
- d) Facing is complete when:
 - i. Complete ribbons of polyethylene have been shaved from the pipe ends, **AND**
 - ii. The pipe ends have smooth, clean and parallel surfaces, **AND**
 - iii. The “stops” on the facing tool and the jaw clamps are in contact, **AND**
 - iv. The rotating surface on the facing tool is able to “freewheel”; there is no resistance from the facer blades being in contact with the pipe ends.
- e) Stop the facer motor and move the pipe ends away from the facer.
- f) Remove the facing tool and clear away all shavings, cuttings and debris. Lightly brush away loose debris from the pipe ends with a clean lint-free cotton cloth.
- g) Avoid any contact with the pipe ends other than above step “f” during and after the facing process.
- i. Any contact with the faced, fusion surface other than the facing tool or the cleaning device requires the operator to repeat the cleaning process as described in Step 1 “Securing the Pipe”.
 - ALWAYS FACE TO THE STOPS!
 - AVOID ANY CONTAMINATION of the faced pipe’s ends.

STEP 3 - Aligning the Pipe Ends ALIGNING THE PIPE ENDS VERIFIES THAT THEY ARE READY FOR THE FUSION PROCESS.

- a) Bring the newly faced pipe ends together at facing pressure to check for parallel alignment (high / low), angular alignment, slippage and unintended movement.
 - i) Inspect the contact of the two pipe ends to ensure that there are no gaps or voids.
 - ii) Visually check for any misalignment (high/low) around the complete outer surface at the point of contact between the two pipe ends.
 - iii) Use a clean straight edge tool to check for any outer surface misalignment (high/low) between the outer surfaces of the two pipe ends.
- b) Adjust any misalignment (High / Low) by tightening the “High”-side jaw clamp. Never loosen the low-side.
- c) NOTE: If **ANY** adjustments are made, redo Step 2 “Facing the Pipe Ends”.
- d) Bring the pipe ends together at the calculated fusion pressure to check for possible slippage or unintended movement. NOTE: If **ANY** slippage or unintended movement occurs, redo Step 2 “Facing the Pipe Ends”.
- e) NEVER ATTEMPT TO HEAT OR FUSE PIPE THAT IS NOT CORRECTLY ALIGNED. Misalignment that exceeds 10% of the pipe wall thickness is incorrect and is not acceptable.

STEP 4 - Melting the Pipe Ends MELTING THE PIPE ENDS AT THE RECOMMENDED TEMPERATURE FOR THE REQUIRED DURATION IS REQUIRED TO CREATE A STRONG, ACCEPTABLE FUSED JOINT.

- a) Check the heater tool surface temperature with a calibrated infrared or surface pyrometer to insure the temperature is within the recommended range: 400°F – 450° F (204°C – 232°C). Follow the manufacturer’s instructions.
- b) Clean the heater surfaces with a clean lint free cotton cloth.
- c) Follow the correct Butt Fusion Joining Procedures for the fusion equipment and pipe material on the jobsite ASTM F2620 is the Standard Practice for Polyethylene pipe.
 - i) Bring the pipe ends into contact with the heating tool surfaces at the fusion pressure.

ii) Maintain fusion pressure² only until first indication of melt is visible around the complete outer edge of both pipe ends indicating that the pipe ends are in full contact with the heater plate around the full circumference.

iii) Immediately reduce pressure from “fusion pressure” to drag pressure without releasing contact between the melted pipe ends and the heating tool surfaces.

Once the pressure is at drag pressure, lock the movable carriage so it can't move in either direction for the “heat soak cycle”. On pipe sizes 14” and larger, maintain the heat soak for a minimum of 4.5 minutes per inch of wall thickness. On manual machines, this will be only enough pressure to maintain contact between the pipe ends and the heating surfaces.

Caution: Care should be taken that pressure never exceeds the drag pressure during the heat soak cycle. THIS IS CRITICAL FOR A GOOD FUSION. During the heat soak cycle the melt bead will form due to the thermal expansion of the melted ends, NOT by any external pressure being applied to the heater plates.

iv) Maintain contact between the pipe ends and the heating tool surfaces until an acceptable melt bead is achieved per Table 1.

Table 1: Minimum Melt Bead Size (Pipe Ends)

Pipe OD	Minimum Melt Bead Size
< 2.37”	1/32”
≥ 2.37” ≤ 3.50”	1/16”
> 3.50” ≤ 8.62”	3/16”
>8.62” ≤ 12.75”	¼”
>12.75” ≤ 24”	3/8”
>24” ≤ 36”	7/16”
>36” ≤ 65”	9/16”

STEP 5 - Joining the Pipe Ends THE PROCESS OF BRINGING THE PIPE ENDS TOGETHER USING the PRE-SET PRESSURE.

a) When the correct melt bead is formed, per the ASTM standard summarized in Table 1, **QUICKLY** separate the pipe ends from the heating tool and remove the heating tool without coming into contact with the melted pipe ends. Next, **QUICKLY** inspect the pipe ends, which should be flat, smooth, free of contamination and completely melted. Concave pipe ends (caused by heating under pressure) are **UNACCEPTABLE** – see Figure A for a photograph representative of this condition. If acceptable, QUICKLY bring pipe ends together and apply fusion pressure. The maximum time allowed for opening the machine, removing the heater and bringing the pipe ends together is shown in Table 2. For tubing sizes, the maximum open/close time is 4 seconds. For manual machines, apply enough force to have the melted ends roll back to the pipe surface. Hold that force until the pipe ends cool to the touch per ASTM F2620.

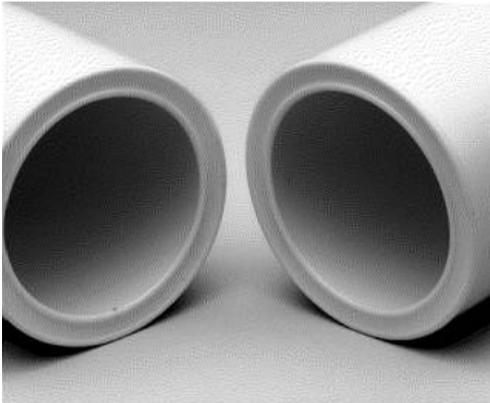


Figure A. UNACCEPTABLE APPEARANCE – Improper Concave Melt Surfaces after Heating; probably caused by heating under pressure.

- b) If there is any indication of an incorrect melt or contamination, **DO NOT CONTINUE**.
- i) Allow the pipe ends to cool and start over with Step 1 “Securing the Pipe”.
- c) A good fusion will form a double roll-back bead onto the pipe surface. Refer to Figure B for bead appearance evaluation.

Table 2: Maximum Heater Plate Removal Time (sec)

Pipe Wall Thickness (in)	Maximum Removal Time (sec)
.17" to .36"	8
>.36" to .55"	10
>.55 to 1.18"	15
>1.18" to 2.5"	20
>2.5" to 4.5"	25

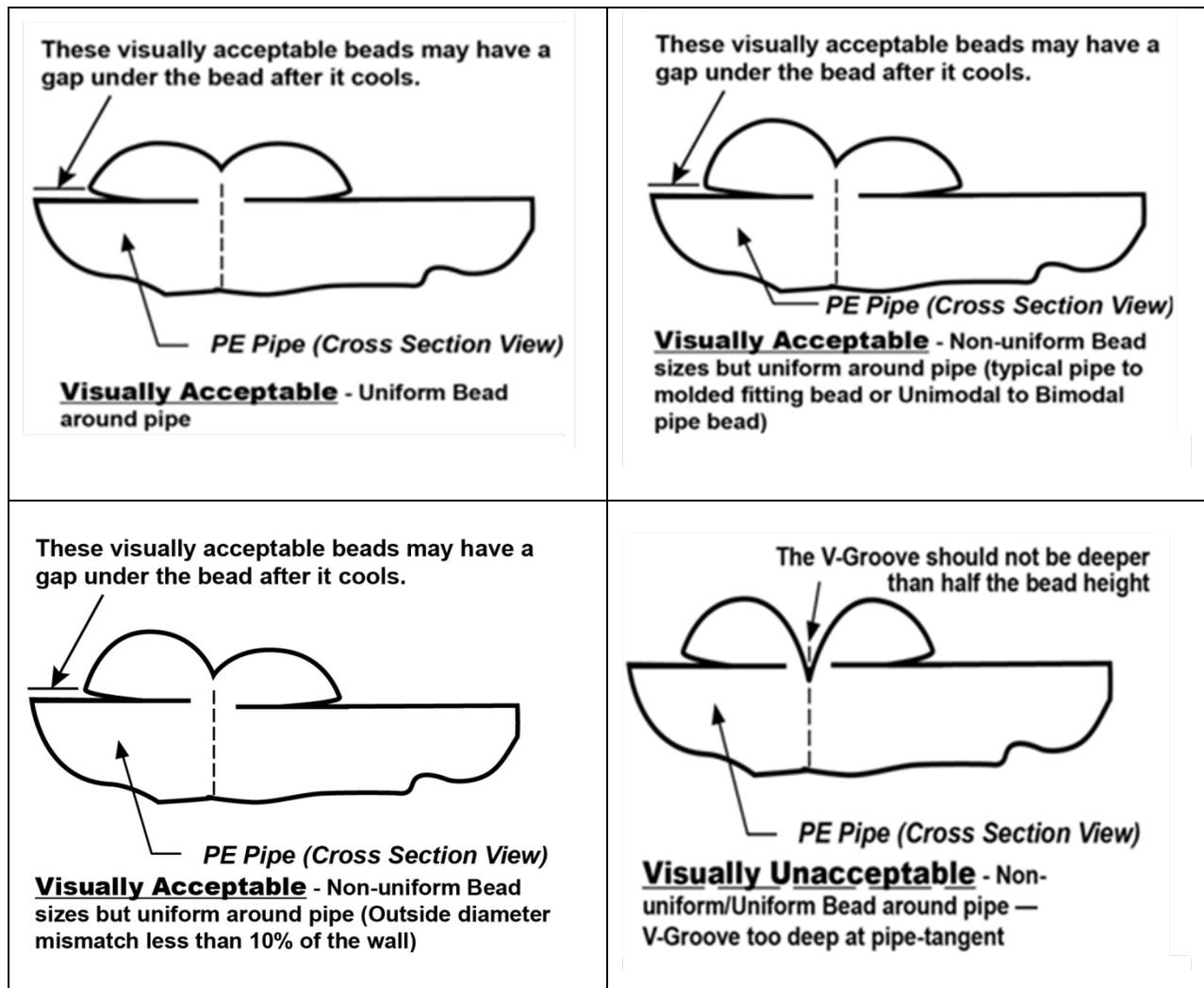


Figure B: Butt Fusion Bead Acceptance Guide

d) If the visual inspection of the fusion joint is not as described, it should be cut out and the process should begin again with Step 1 “Securing the Pipe”.

STEP 6 - Holding the Pipe HOLDING THE PIPE, AND ALLOWING IT TO COOL COMPLETELY, IS NECESSARY FOR JOINT STRENGTH.

- a) Maintain the correct fusion pressure until the joint has cooled.
 - i) Allow the joint to cool for 11 minutes per inch of pipe wall thickness. For ambient temperatures 100° F and higher, additional cooling time may be needed. Note that in accordance with ASTM F 2620 recommendations, “Pouring water or applying wet cloths to the joint to reduce cooling time is not acceptable. Applying chilled air is acceptable only as part of a controlled cooling cycle procedure where testing demonstrates that acceptable joints are produced using the controlled cooling cycle procedure.”
- b) Avoid pulling, installation, pressure testing, or rough handling of the fused pipe for an additional 30 minutes or longer past completion of the last joint in the pipeline.
- c) Re-inspect the butt fusion joint.
 - i) Both sides of the double roll-back bead should be rolled to the pipe surface.
See Figure B above for proper bead appearance

Making and Testing Sample Butt Fusion Joints.

In order to verify the quality of the fusion process, including fusion operator skills and machine function, it is required that sample fusion joints be made for testing using the fusion procedures described in ASTM F2620-06 and in PPI TR 33 in conjunction with those outlined in this document. These test samples are for pipe with a wall thickness of 1” or less. For thicker wall applications, contact the pipe manufacturer for the appropriate test. The following describes the preparation of the test samples and the details of the testing procedure

- 1) Complete a minimum of two butt fusion joints for test using the procedures described in this document,
- 2) Complete a visual inspection of the joints to confirm their suitability for testing

- 3) Allow the fusion joint samples to cool to a temperature ranging between 65°F (18°C) and 80°F (27°C).
- 4) Cut a strip from each of the sample fusion joints for testing.
 - a) The fusion joint should be in the middle of the cut length specimen.
 - b) The overall length of the strip should be 15x the wall thickness (a minimum of 6") on each side of the fusion
 - c) The overall width of the strip should be no less than 1-1/2x the wall thickness (a minimum of 1").
- 5) Bend the strips in a "back and forth" motion, with the ends touching each other at the completion of each motion.

A correct fusion joint should not crack or fail, or produce gaps or voids during this testing procedure. However, It should be noted that if testing is performed when the temperature of the samples is outside the 65°F to 80°F range specified in 3) above, a false result may be obtained.

Training Record per PPI TN 42-2013 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects

Date of Training: _____

Name of Trainer: _____

Name of Trainer's Company or Employer: _____

Name of Trainee Fusion Operator: _____

Name of Trainee Fusion Operator's Employer: _____

Name and Location of Project: _____

Fusion Machine(s) Used:

1. Manufacturer: _____ Machine: _____ Serial No.: _____

2. Manufacturer: _____ Machine: _____ Serial No.: _____

Pipe Samples Fused:

1. OD _____ SDR/DR _____ Product ID/Manufacturer _____

2. OD _____ SDR/DR _____ Product ID/ Manufacturer _____

Training Completed

Number of Joints Tested: ____ Number Passed Test: ____ Number Failed Test _____

Training on Butt Fusion above ground _____ Training on Butt Fusion in ditch _____

Operator _____ Date: _____

Trainer _____ Date: _____

NOTES: 1. A Copy of this fully completed Training Record must be retained by the Fusion Operator and be available for inspection at all times while performing fusion joining operations on the project.

2. The Trainer must also retain a fully completed file copy of this Training Record for future reference.

APPENDIX

Butt Fusion Joints – Visual Appearance Guidelines

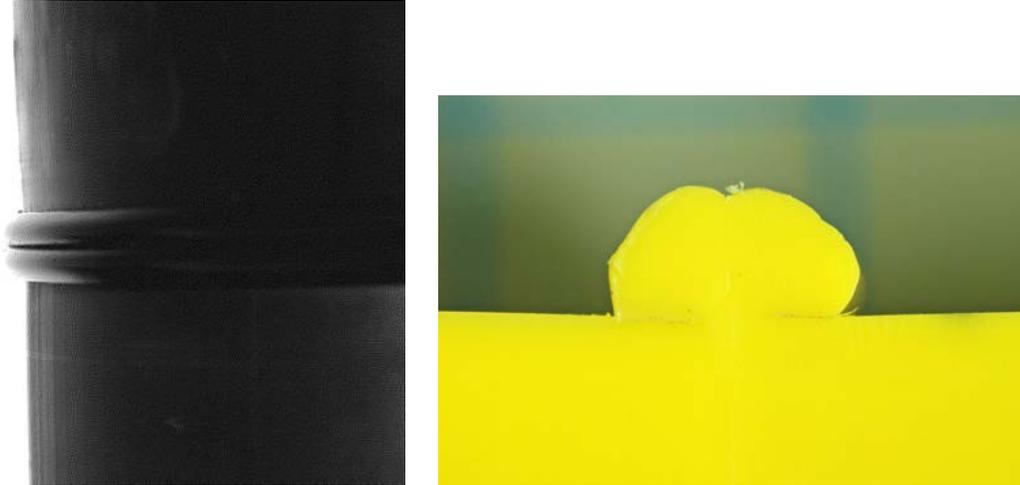


Figure 1. ACCEPTABLE APPEARANCE - Proper Double Roll-back Bead and Proper Alignment

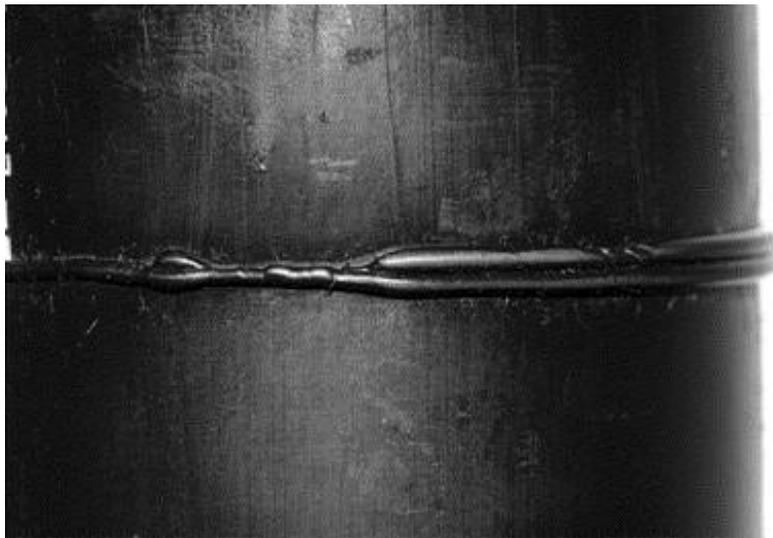


Figure 2. UNACCEPTABLE APPEARANCE – Incomplete Face-off



Figure 3. UNACCEPTABLE APPEARANCE – Mitered Joint – Improper ‘High-Low’ Pipe Alignment



Figure 4. UNACCEPTABLE APPEARANCE – Unintentional Mitered Joint – Improper Alignment in Fusion Machine



Figure 5. UNACCEPTABLE APPEARANCE – Contamination in Joint

Appendix VII
AMEC Final Benthic



FINAL

**Application of available multibeam acoustic and seascape data to map
proposed marine finfish production locations in Placentia Bay,
Newfoundland**

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16 June 2017

Amec Foster Wheeler Project #: TF1791503



IMPORTANT NOTICE

This report was prepared exclusively for Grieg NL Seafarms Ltd. by Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Grieg NL Seafarms Ltd. only, subject to the terms and conditions of its contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

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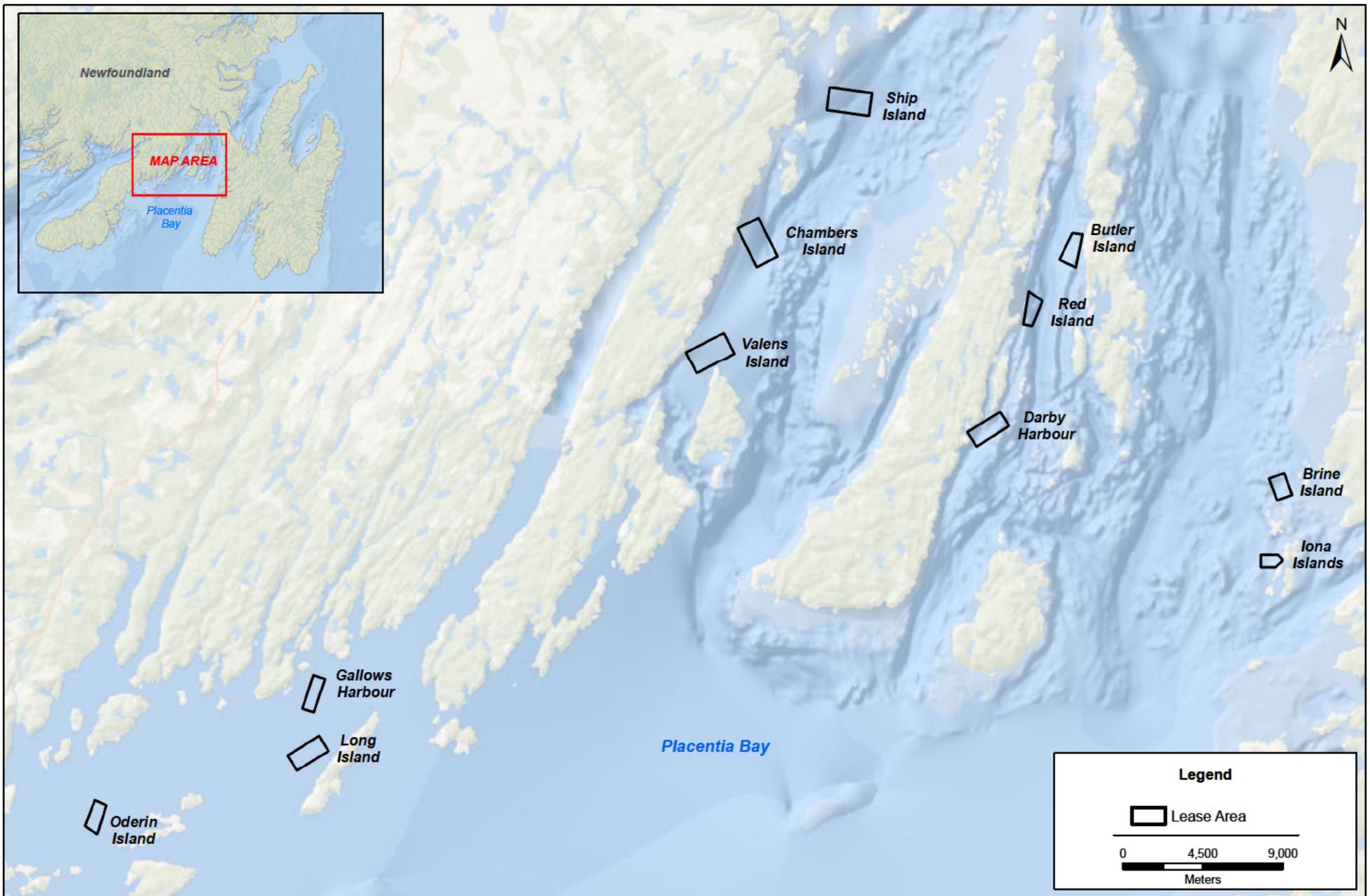
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Appendix A Grieg NL Benthic Depositional Modeling Report36

1.0 CONTEXT

Amec Foster Wheeler, Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler) is pleased to submit this report of benthic mapping and characterization at your proposed marine production sites in Placentia Bay, Newfoundland for the purpose of supporting your approval process with the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements (AAR, 2015). This report summarizes benthic habitat types according to AAR classification requirements to facilitate consistent interpretation of all production sites as hard or soft bottom for future operational monitoring programs at the eleven proposed marine production sites in Placentia Bay, Newfoundland (Figure 1).



NOTE:
 1. ALL DIMENSIONS ARE IN METRES.
 2. DO NOT SCALE FROM DRAWING.
 3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
 4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
 5. THIS DRAWING CONTAINS INTELLECTUAL PROPERTY OF THE CLIENT AND MAY NOT BE REPRODUCED OR COPIED WITHOUT THEIR WRITTEN CONSENT.

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DWN BY: JA
 CHK'D BY: AE
 DATUM: NAD83
 PROJECTION: ZONE 21N (M)
 SCALE: As Shown

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION
 TITLE: LEASE AREAS

DATE: May 2017
 PROJECT No. TF1791503
 REV No. 0
 FIGURE No. 1

Grieg NL Seafarms Ltd.

Application of Available Multibeam Acoustic and Seafloor Data to Map Proposed Marine Finfish Production Locations in Placentia Bay, Newfoundland (Final)

Amec Foster Wheeler Project #: TF1791503

16 June 2017

2.0 BACKGROUND

An essential step toward implementing effective management strategies for ocean systems is to identify biophysical patterns and processes that delineate benthic system functions (reviewed by Brown et al., 2011). The process of producing seafloor habitat maps incorporates disparate datasets from biological, geological, hydrographical and geophysical inputs to produce simplified spatial representation of the seafloor relating to the distribution of biological characteristics (Brown et al., 2011).

However, in the sublittoral environment, limitations of conventional *in situ* sampling methods (such as benthic grabs, dredges, video, etc.) impair the ability to synthesize the complexities of benthic system interactions as they provide detailed information on the seafloor that they sample, but on a very localized/small scale; therefore, it remains challenging to derive accurate representation of the biophysical characteristics of the seafloor in an area without extensive survey designs and tightly spaced sampling station transects (reviewed by Brown et al., 2011). Therefore, application of acoustic survey techniques such as side-scan sonar systems and multibeam echo sounders provide tools that enable wide-scale reconnaissance style surveying to produce accurate, aerial-like images of the seafloor (reviewed by Brown et al., 2011).

Multibeam echosounders are able to provide bathymetric data detailing the terrain and structure (e.g., rugosity and/or steepness) of the seafloor in addition to information that can provide an indication of sediment grain size and hardness (Dolan et al., 2009; Kaplan et al., 2010). The latter is derived from acoustic response (reflection) of the seafloor to the multibeam acoustic waves, this data, called backscatter, can be used for interpretation of some aspects of the physical habitat such as morphological structures and slopes (Dolan et al., 2009; Kaplan et al., 2010). However, interpretation of backscatter data also requires supportive *in situ* observations using conventional benthic survey methods to validate the interpretations and ground-truth the data (Dolan et al., 2009; Kaplan et al., 2010). The combination of multibeam acoustic survey data with conventional *in situ* sampling can be reconciled with a Geographic Information System (GIS) to synthesize seafloor habitat characterization maps (seascapes) according to geomorphology, texture and biota (Dolan et al., 2009; Brown et al., 2011; Shaw et al., 2011; 2011; Todd and Greene, 2007; Whitmire et al., 2007).

Grieg NL Seafarms Ltd.

Application of Available Multibeam Acoustic and Seafloor Data to Map Proposed Marine Finfish Production Locations in Placentia Bay, Newfoundland (Final)

Amec Foster Wheeler Project #: TF1791503

16 June 2017

3.0 APPROACH

The Geologic Survey of Canada (GSC) and Canadian Hydrographic Service (CHS) conducted systematic mapping of Placentia Bay, Newfoundland using multibeam sonar and surveyed with sub-bottom profilers (Shaw et al., 2011). Interpretation of the multibeam data was supported by seismic data, sidescan sonograms, bottom photographs, video, submersible observations and grab samples to generate a high-resolution seafloor dataset (Shaw et al., 2011). The output was georeferenced spatially using GIS software (ESRI's ArcGIS Software Package) and then digitized and coded. High-resolution outputs (5m grid resolution GIS Shapefiles) and graphical outputs have been generated according to referenced coordinates.

Proposed lease site area coverage represented by multibeam data was calculated and the non-surveyed areas were composited with CHS bathymetric data when both sources were in alignment where they interfaced. For each site the percentage represented by multibeam data is reported, as is the percentage for each habitat type defined therein.

Lease areas with less than 90% multibeam survey coverage were composited with CHS 10m resolution bathymetry data and surveyed using drop video at 100 m grid intervals by Grieg NL personnel. The video survey locations are indicated in this report and results of the video surveys are reported separately by Grieg NL.

All sites are depicted with corresponding carbon depositional contours previously calculated using DEPOMOD software (Appendix A) and represented at the same spatial scale as the multibeam outputs.

The baseline site characterization data was used to designate potential lease sites as hard bottom according to the *Monitoring Protocol for Hard Bottom Benthic Substrates under Marine Finfish Farms in Newfoundland and Labrador (NL)* under Annex 9 of the AAR if "more than 50% of the lease area is hard bottom composed of rockwall, bedrock, boulders, rubble, cobble, gravel, or hard packed finer substrates" (Annex 9; AAR, 2015).

4.0 RESULTS

Four of the proposed lease sites (Oderin Island, Valens Island, Ship Island, and Red Island) had 100% site coverage with the multibeam data (Table 1). An additional four sites had greater than 90% site coverage, including Chambers Island, Butler Island, Darby Harbour and Iona Island (Table 1). For the remaining sites, Long Island had 69.34% multibeam survey coverage, Gallows Harbour had 15.71% survey coverage, and Brine Island was represented by 1.71% survey coverage.

Table 1 Grieg NL lease site coverage with CHS or Multibeam bathymetry

Lease Area Name	Total Lease Area (km ²)	Area multibeam (km ²)	Area CHS Area (km ²)	% Canadian Hydrographic Service	% Multibeam
Gallows Harbour	1.40	0.22	1.18	84.29	15.71
Long Island	2.12	1.47	0.65	30.48	69.34
Oderin Island	1.22	1.22	0.00	0.00	100.00
Valens Island	3.17	3.17	0.00	0.00	100.00
Chambers Island	3.15	3.09	0.05	1.59	98.10
Ship Island	3.13	3.13	0.00	0.00	100.00
Butler Island	1.39	1.37	0.02	1.44	98.56
Red Island	1.19	1.19	0.00	0.00	100.00
Darby Harbour	2.08	1.94	0.15	7.08	93.27
Brine Island	1.17	0.02	1.15	98.29	1.71
Iona Islands	0.66	0.63	0.03	4.55	95.45

4.1 Benthic Habitat Types in Proposed Grieg NL Marine Production Lease Areas

Use of the Shaw et al. (2011) seascape dataset for benthic habitat mapping reveals up to three benthic habitat types at the proposed production lease sites, two are consistent with hard bottom classification: sub-littoral bedrock and deep-water bedrock, and one is consistent with soft-bottom classification: deep-water muddy.

The predominant hard bottom seascape type among lease areas is **deep-water bedrock**. This seascape is characterized as having high-relief ridges, ledges, and pinnacles; however the topographic relief of these features is more subdued compared to those in shallower regions (Shaw et al., 2011). The sediment is composed of rock, muddy gravel, and gravelly mud and is relatively barren of biota, other than anemones (*Hormathia nodosa*) and tube burrow openings in sediment (Shaw et al., 2011). The depth ranges for this habitat type vary depending on the sites, and these are discussed separately for each lease area below.

The balance of hard-bottom areas among lease areas is **sub-littoral bedrock** seascape, which is characterized as being composed of rock (high backscatter) and gravel (high backscatter) with morphology of high relief ridges, ledges and pinnacles (Shaw et al., 2011). There is commonly a

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veneer of sand and gravel, with thicker sediments in pockets (Shaw et al., 2011). Associated biota include attached fauna such as encrusting red algae (*Lithothamnion sp.*) and seaweeds on rocks (Shaw et al., 2011).

The only soft-bottom type among the proposed lease areas is **deep-water muddy** seascape. This habitat is characterized as having very low relief (flat) except in areas of “pockmarks” and being composed of mud, silty mud, and sandy mud (low backscatter) (Shaw et al., 2011). Biota that may be associated with this habitat include infaunal annelids and bivalves, gastropods, crustaceans, including snow crabs (*Chionoecetes opilio*), and shrimps (*Pandalus sp.*) (Shaw et al., 2011).

4.2 Benthic habitat type per individual lease area

The habitat types, depths and depositional contours for each lease site are described below. An overall site designation as hard or soft bottom is proposed according to the data available.

4.2.1 Oderin Island

Oderin Island is located in the southwest region of Placentia Bay (Figure 1), in the Rushoon Bay Management Area (BMA). This site ranges in depth from 39 in the southeast corner of the lease area to 98 m in the northeast and southern regions of the lease area (Figure 2). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (61.26%) seascape type is **deep-water bedrock (Table 2)**. This habitat type spans from the southwest corner of the lease area across the majority of the northern half (Figure 2) and includes several slight pinnacle formations not exceeding this depth range.

The remaining hard-bottom regions of this lease area are **sub-littoral bedrock** seascape (4.70%). This habitat type is confined to the southernmost corner of the proposed Oderin Island lease site at a depth range of approximately 35-70m.

The soft-bottom area of the lease site (34.24%) is **deep-water muddy** seascape. This seascape type is located primarily in the bottom half of the proposed lease site and ranges in depth from approximately 72 to 98m (which includes the deepest region of this proposed lease area). In the northernmost region of the proposed lease area there is an additional deep (95m) area of this seascape type.

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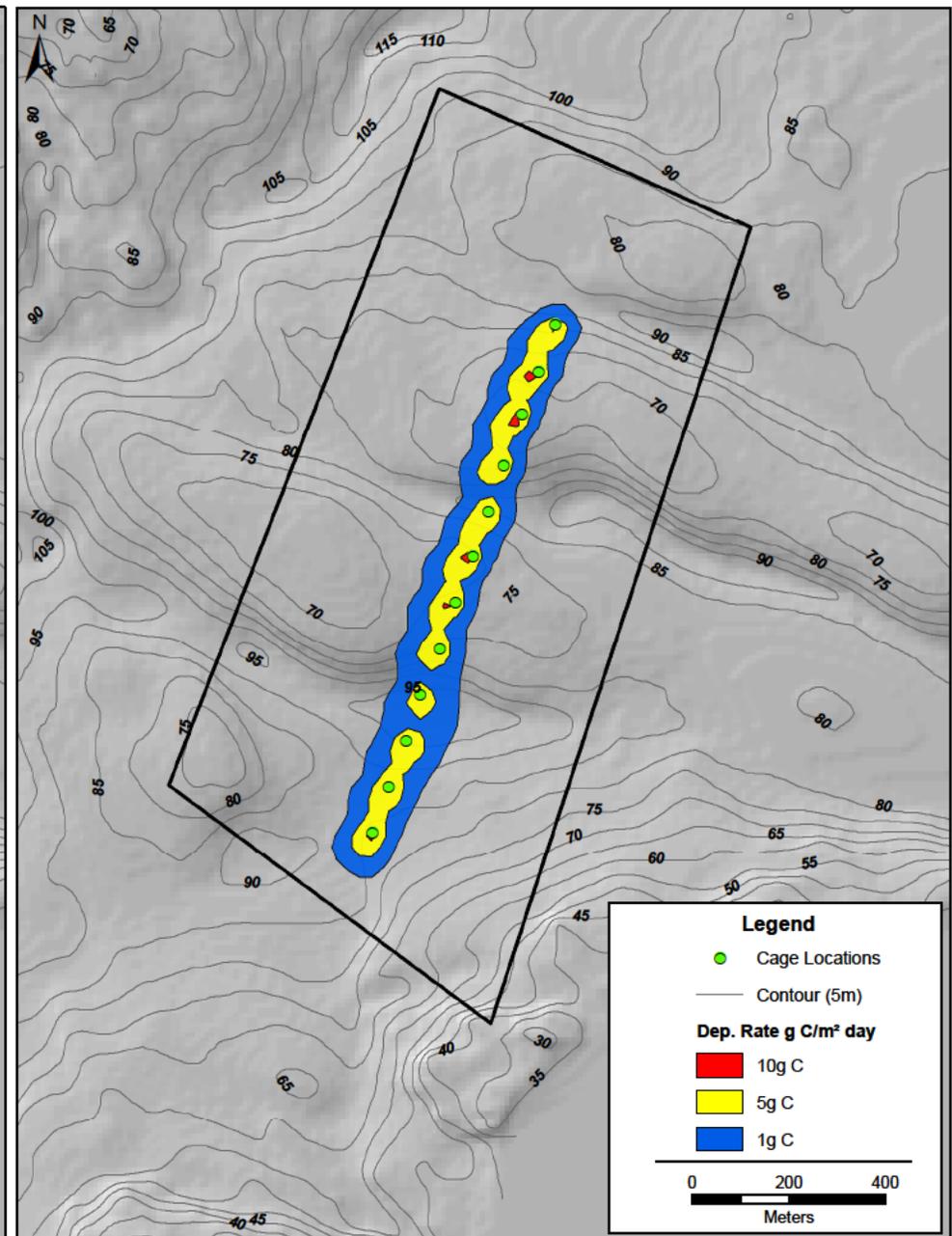
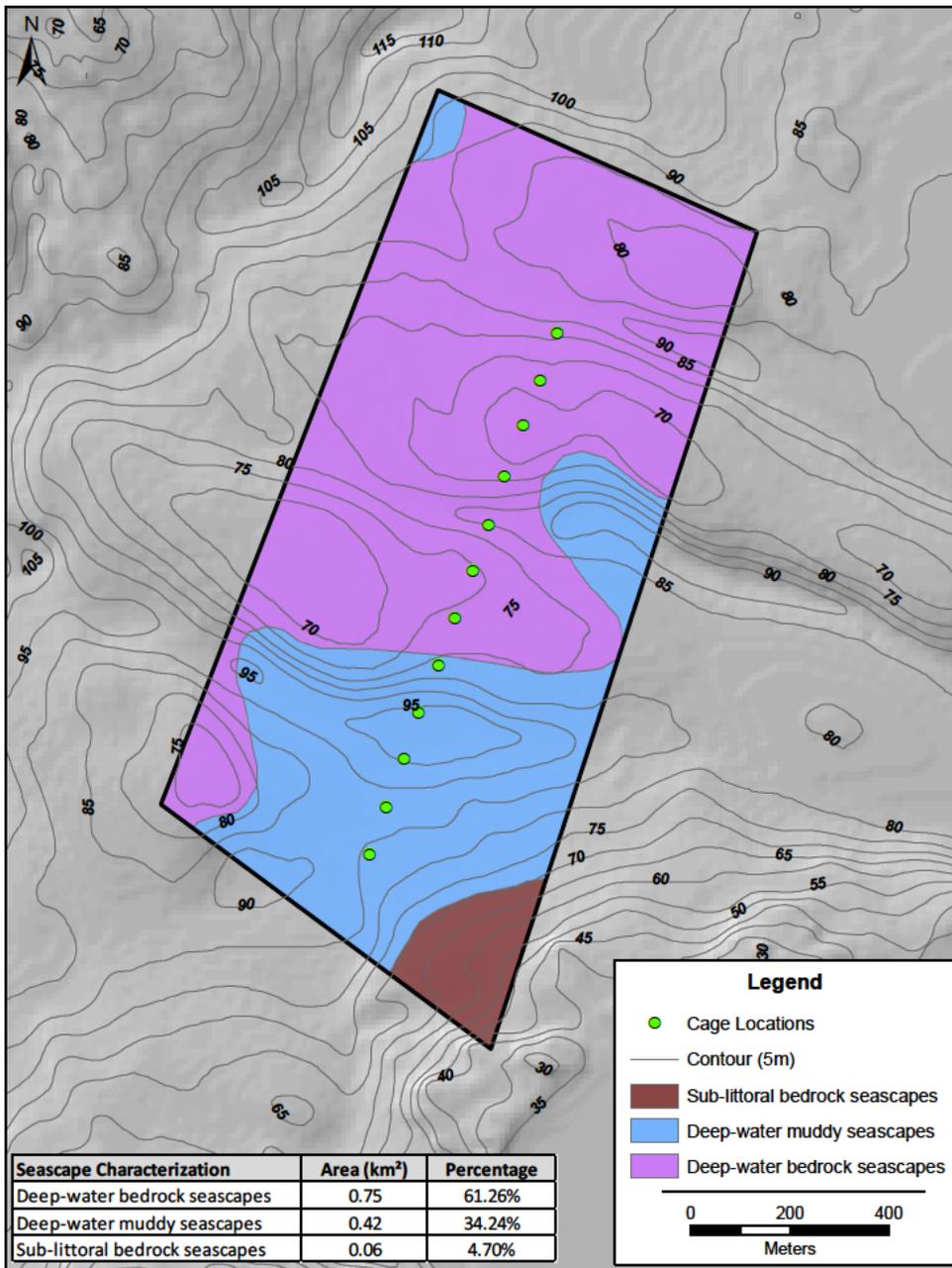
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Table 2 Summary of Oderin Island benthic habitat types by spatial coverage.

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Oderin Island	Deep-water bedrock seascapes	0.75	61.26	61.26
	Sub-littoral bedrock seascapes	0.06	4.70	4.70
	Deep-water muddy seascapes	0.42	34.24	
Total		1.22		65.96
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				

Overall, the majority (65.96%) of the Oderin Island lease area is hard-bottom (Table 2) and the 1 g depositional contour is primarily over deep-water bedrock seascape (Figure 2).



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 REV No. 0
 FIGURE No. 2

4.2.2 Long Island

Long Island is located in the southwest region of Placentia Bay (Figure 1), also in the Rushoon Bay Management Area (BMA). In the area represented by the seascapes data, this site ranges in depth from 75 m near the northern corner of the lease area to 180 m in the southwest region of the lease area (Figure 3). The majority (69.34%) of this proposed lease site is represented by the multibeam survey data. The predominant (47.70%) seascapes type is **deep-water bedrock (Table 3)**. This habitat type spans between the northern corner and southern corners of the lease area and bifurcates towards the west around a deep-water muddy seascapes in the middle of the western half of the lease area (Figure 3), representing 22.68% of the lease area seascapes composition.

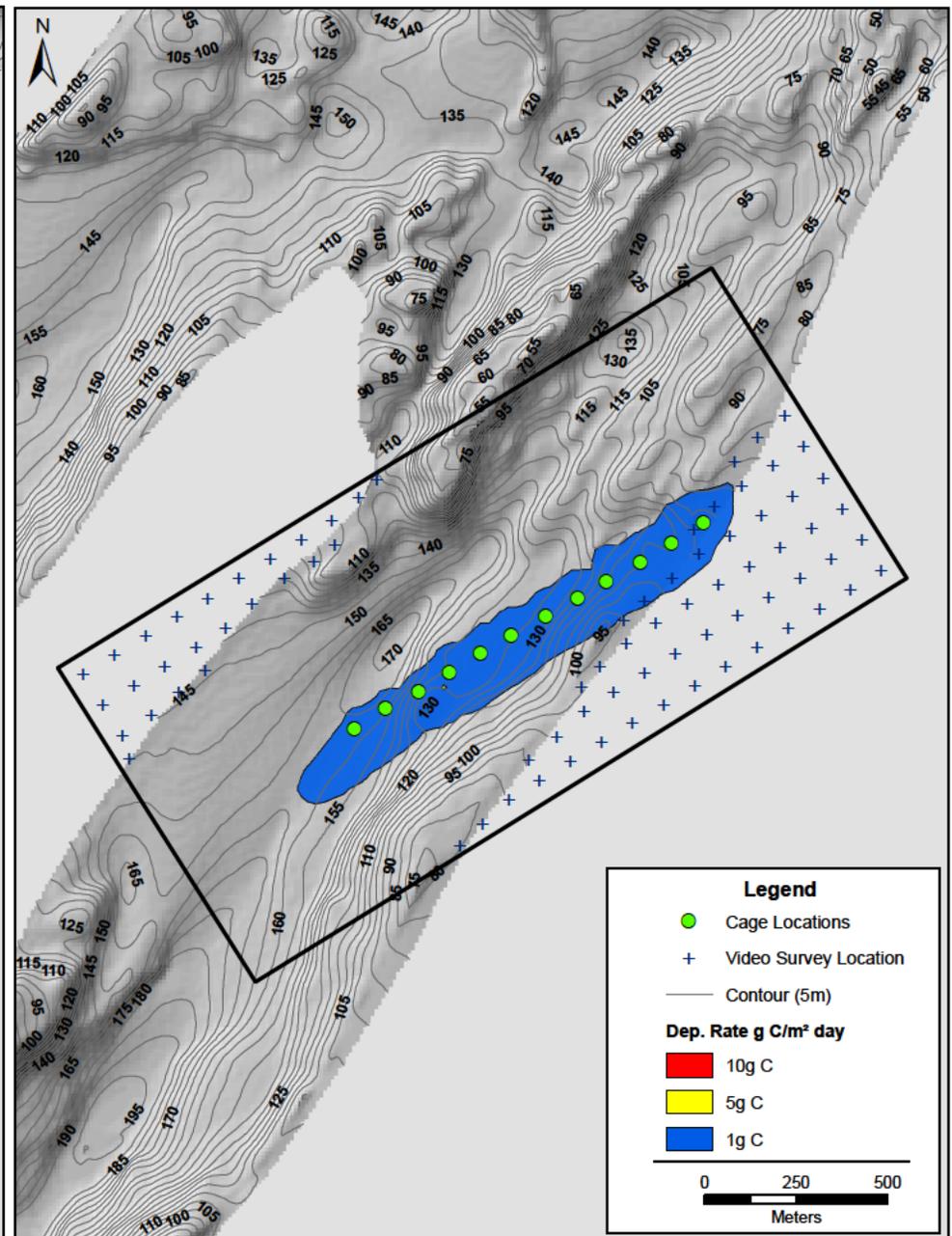
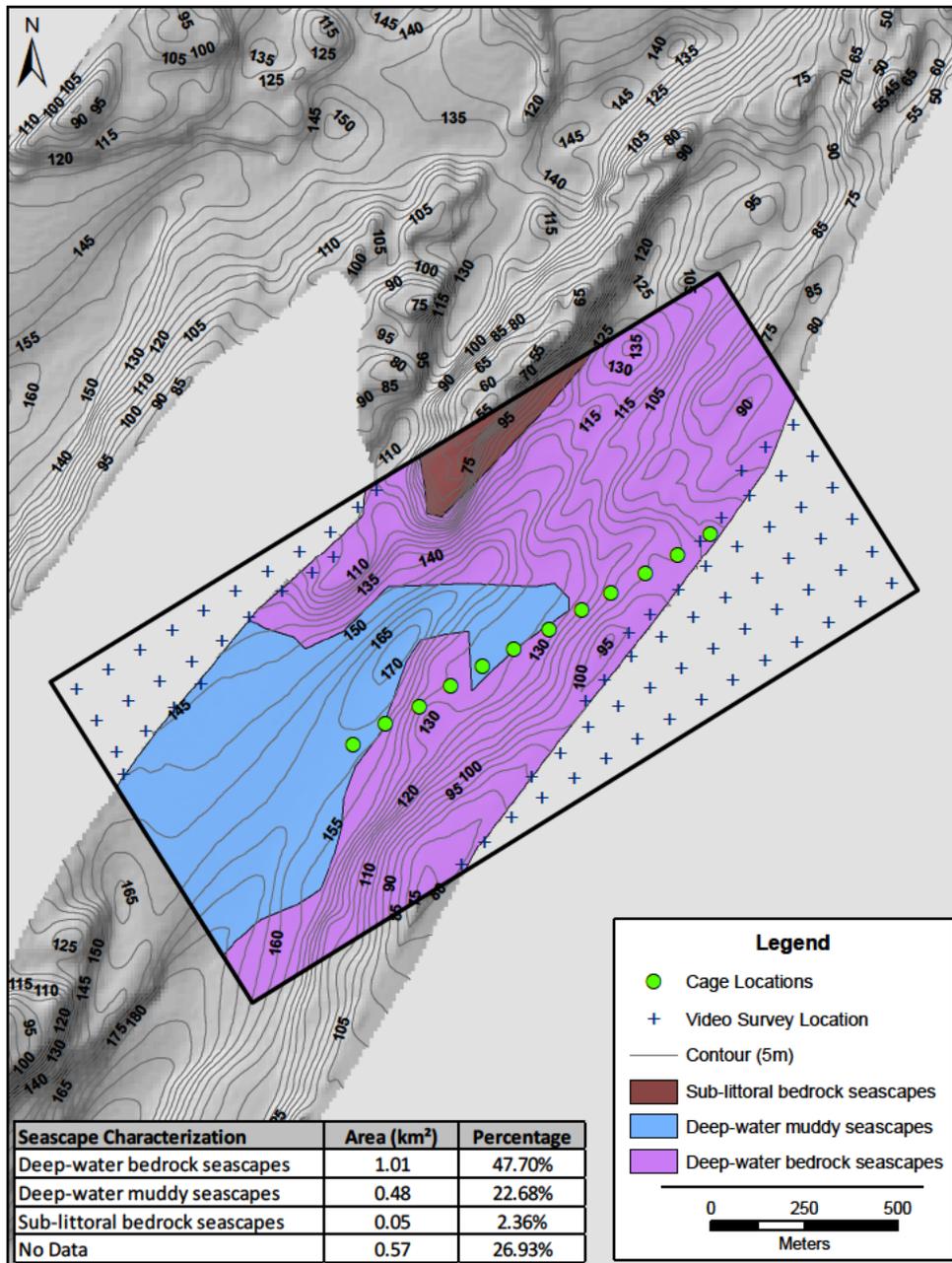
The remaining hard-bottom region of this lease area that has been characterized by the seascapes data is **sub-littoral bedrock (2.36%)**. This habitat type is confined towards the northern shallower region of the lease area.

The remainder of this lease area (26.93%) is not represented by the seascapes survey and this area was instead surveyed by Grieg NL using drop video at the station locations illustrated in Figure 3. Those survey results are reported separately.

Overall, according to the multibeam data the majority (50.60%) of the Oderin Island lease area is hard-bottom (Table 3) and the 1 g depositional contour is primarily over deep-water bedrock seascapes (Figure 3).

Table 3 Summary of Long Island benthic habitat types by spatial coverage.

Proposed Marine Site	Seascapes Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Long Island	Deep-water bedrock seascapes	1.01	47.70	47.70
	Sub-littoral bedrock seascapes	0.05	2.36	2.36
	Deep-water muddy seascapes	0.48	22.68	
	No multibeam data	0.57	26.93	
Total				50.60
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				



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 FIGURE No. 1

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4.2.3 Gallows Harbour

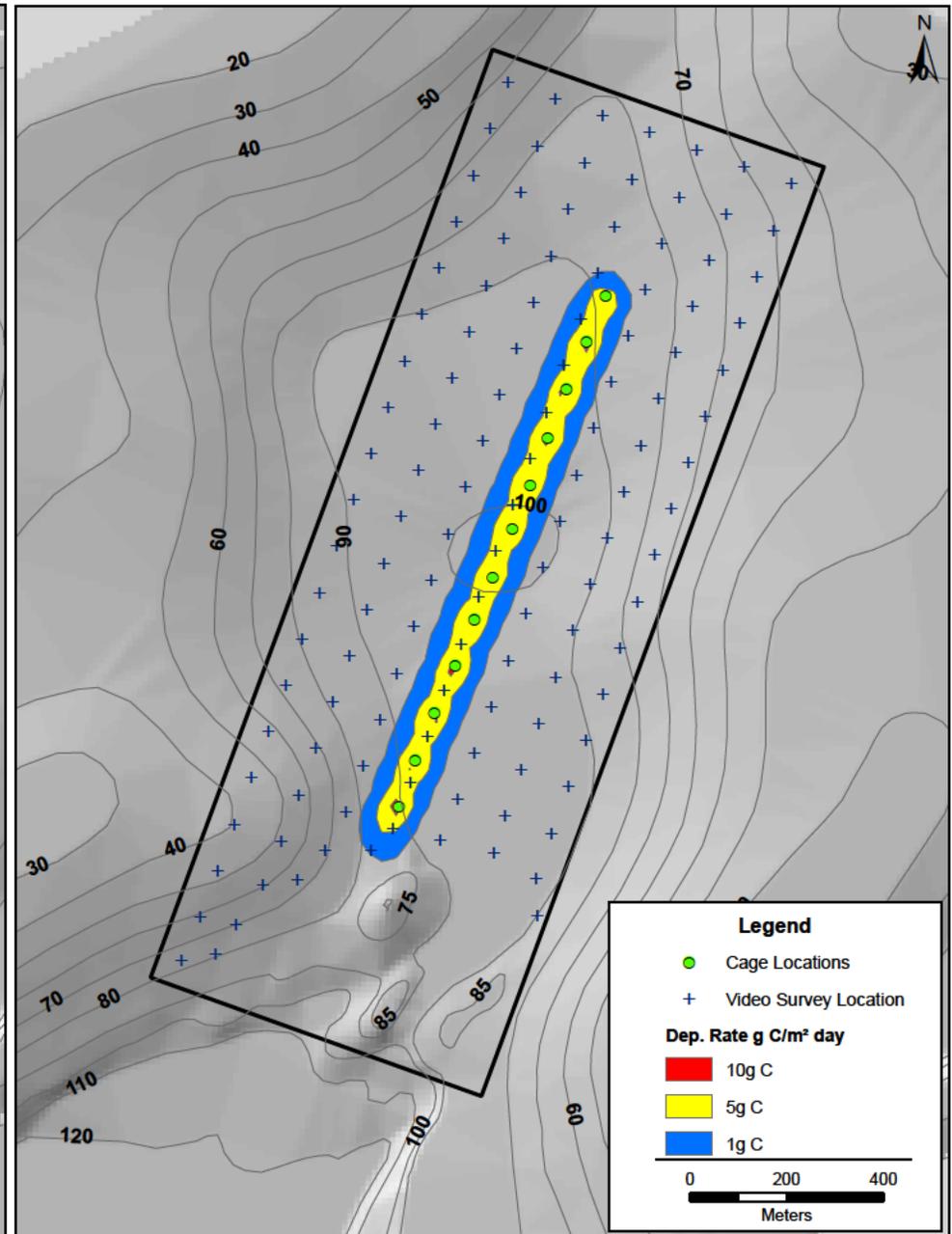
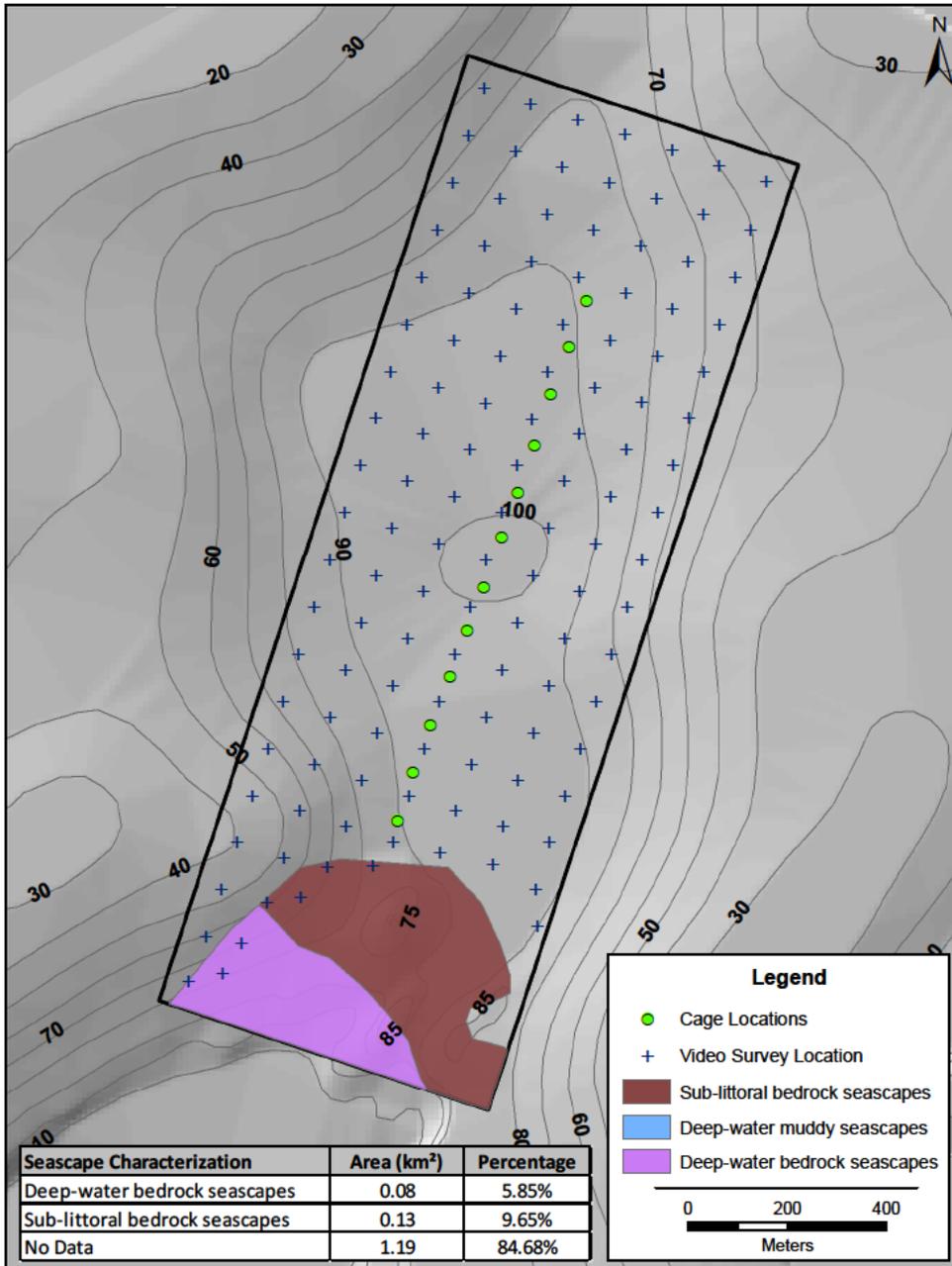
Gallows Harbour is also located in the southwest region of Placentia Bay (Figure 1), in the Rushoon BMA. This site ranges in depth from 40 m in the southwest corner of the lease area to 100 m in the centre of the lease area (Figure 4). Only a portion (15.50%) of this proposed lease site is represented by the multibeam survey data, of this 9.65% of the lease area is **sub-littoral bedrock** (Table 4). This habitat type spans from the southeast corner of the lease area towards the centre (Figure 4) and south of this is a region of deep-water bedrock. The majority of this sight required conventional video survey at 100m grid intervals (video locations indicated in Figure 4). That survey information is provided in a separate report from Grieg NL.

The characterization of the Gallows Harbour Lease Area will depend on the results of the video survey of the remaining 85% of the lease area including in the area of the predicted 1 g/ day depositional contour.

Table 4 Summary of Gallows Harbour Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Gallows Harbour	Deep-water bedrock seascapes	0.08	5.85	5.85
	Sub-littoral bedrock seascapes	0.13	9.65	9.65
	No multibeam data	1.19	84.50	
Total		1.40		15.50

*The AAR definition of hard bottom is "substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines." (AAR, 2015)



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 FIGURE No. 4

4.2.4 Valens Island

Valens Island is located towards the inland region of Placentia Bay (Figure 1), in the southwest region of the Merasheen BMA. This site ranges in depth from 58 m in the westernmost corner of the lease area to 308 m in the centre of the northeastern half of the lease area (Figure 5). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (53.80%) seascape type is **deep-water bedrock (Table 5)**. This habitat type undulates around the perimeter of the lease area and is continuous across the northeast margin of the lease area (Figure 5) there are several slopes and pinnacle formations in these habitat areas.

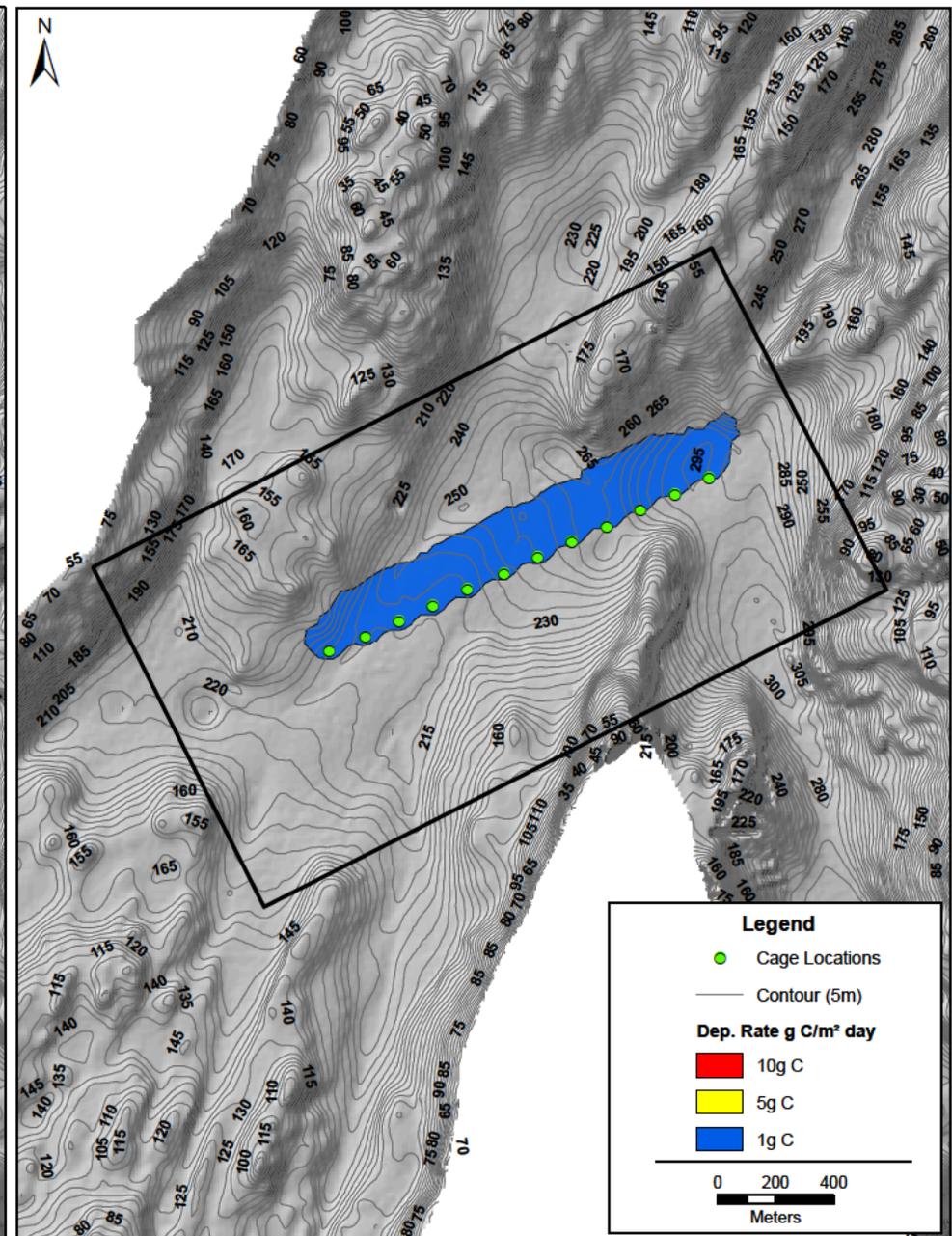
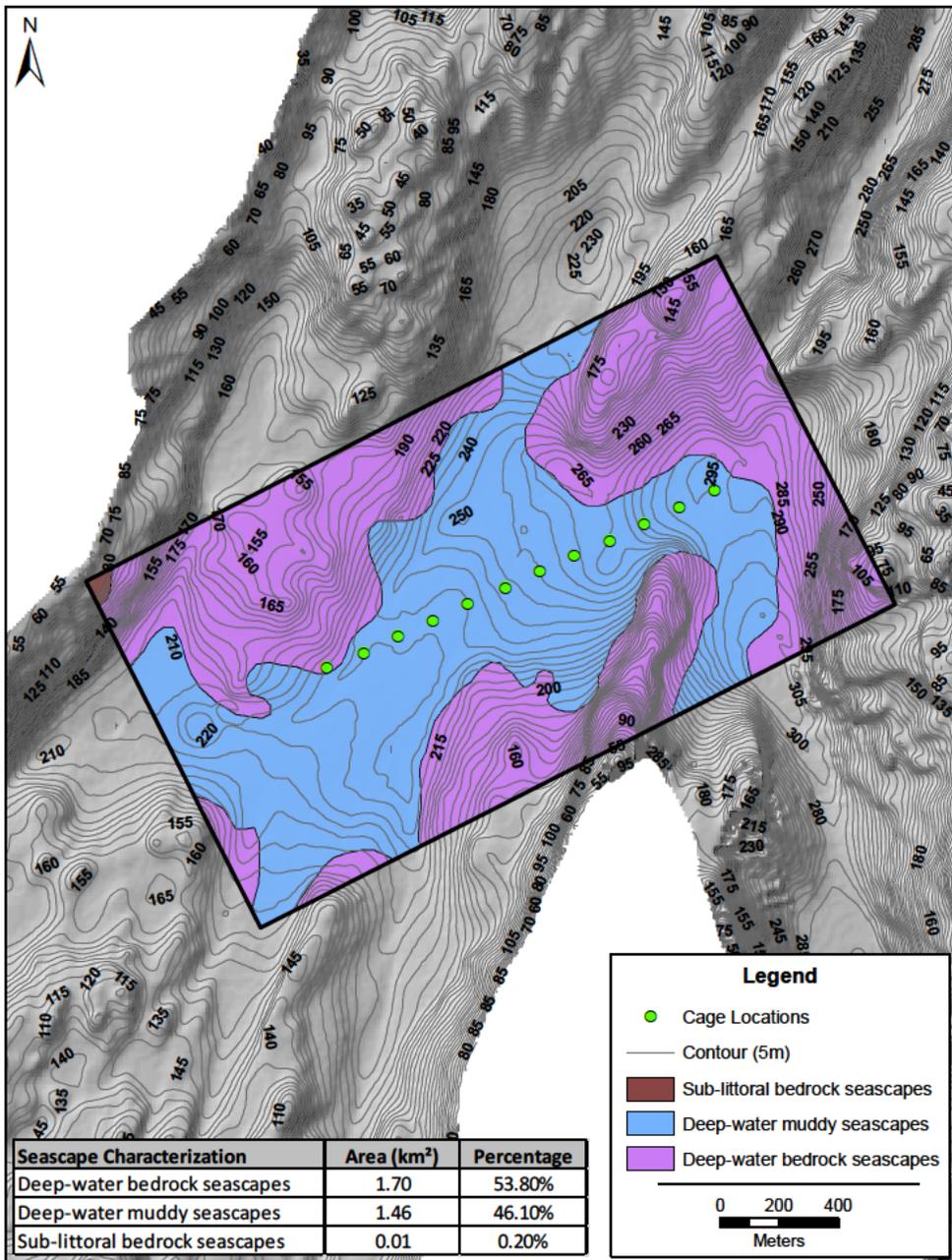
The remaining hard-bottom regions of this lease area are **sub-littoral bedrock** seascape (0.20%). This habitat type is confined to the western-most corner of the proposed Valens Island lease area projecting towards the coastal shoreline.

The soft-bottom area of the lease site (46.10%) is **deep-water muddy** seascape. This seascape type is located primarily along the centre of the proposed lease site and diverges out in north and south projections around deep-water bedrock seascapes.

Overall, the majority (54.00%) of the Valens Island lease area is hard-bottom (Table 5) and the 1 g depositional contour is primarily over deep-water muddy seascape (Figure 5).

Table 5 Summary of Valens Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Valens Island	Deep-water bedrock seascapes	1.70	53.80	53.80
	Sub-littoral bedrock seascapes	0.01	0.20	0.20
	Deep-water muddy seascapes	1.46	46.10	
Total		3.17		54.00
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				



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 FIGURE No. 5

4.2.5 Chambers Island

Chambers Island is located towards the inland region of Placentia Bay (Figure 1), in the western region of the Merasheen BMA. This site ranges in depth from 16 m in the westernmost corner of the lease area to 308 m in the western-most corner of the lease area (Figure 6). The majority (99.95%) of this proposed lease site is represented by the multibeam survey data. The predominant (51.70%) seascape type is **deep-water bedrock (Table 6)**. This habitat type extends across the northern region of the lease area as well as along the majority of the southern perimeter of the lease area continuous across the northeast margin of the lease area (Figure 6).

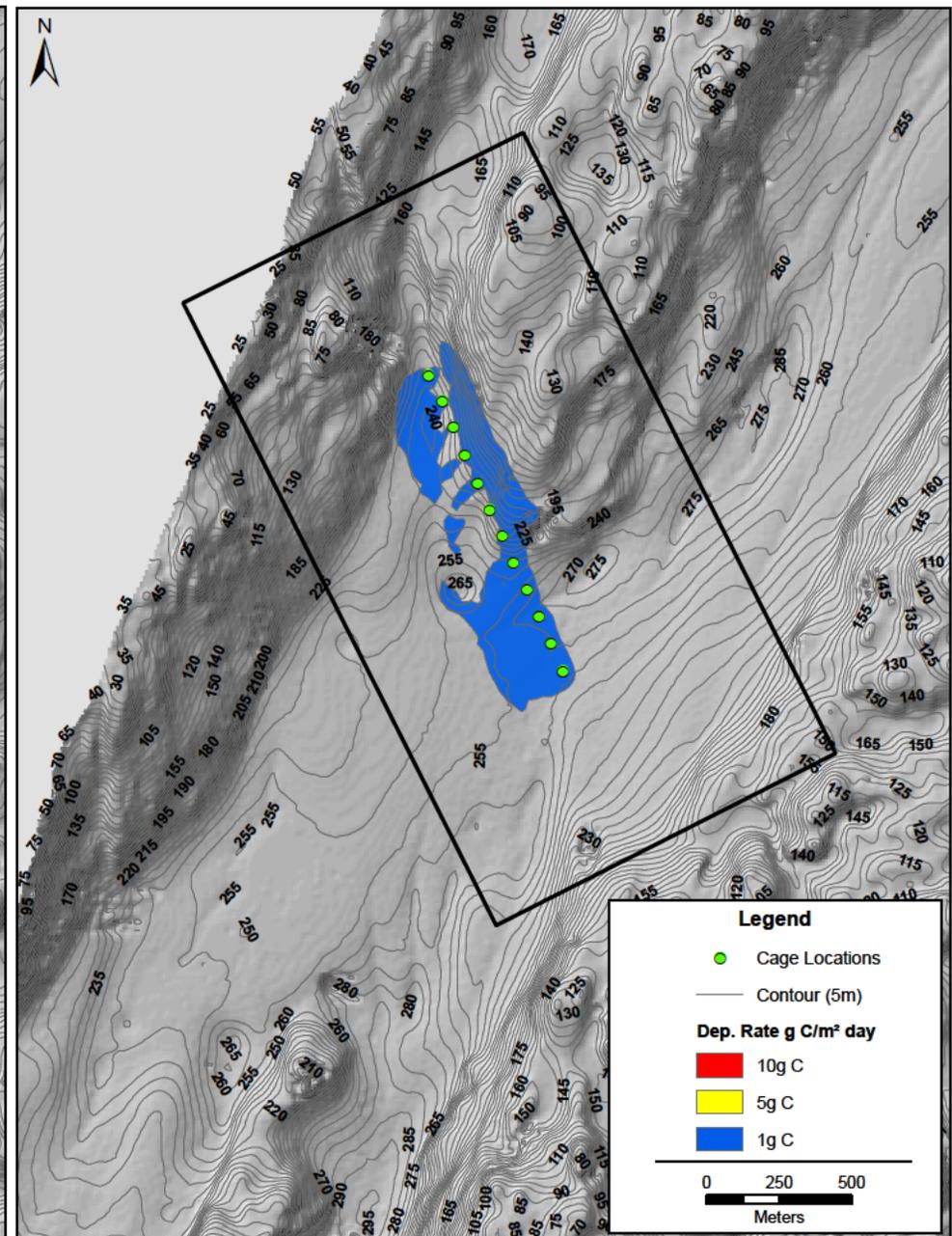
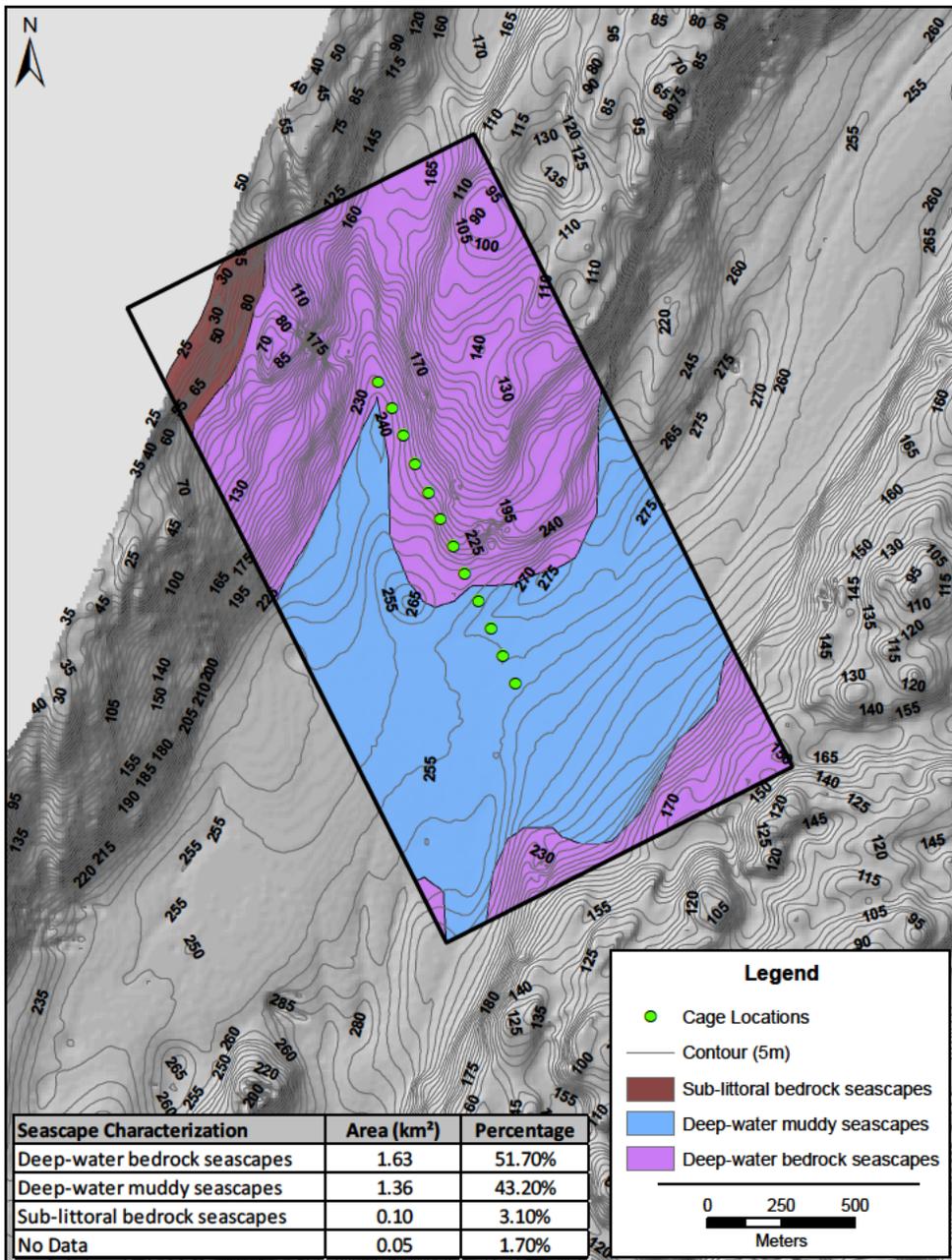
The remaining hard-bottom region of this lease area is **sub-littoral bedrock** seascape (3.10%). This habitat type is confined to the western-most corner of the proposed Valens Island lease area and ascending towards the coastal shoreline.

The soft-bottom area of the lease site (43.20%) is **deep-water muddy** seascape. This seascape type transverses the southern mid-section of the proposed lease site.

Overall, the majority (54.80%) of the Valens Island lease area is hard-bottom (Table 6) and the 1 g depositional contour is over deep-water bedrock and deep-water muddy seascapes (Figure 6).

Table 6 Summary of Chambers Island Benthic Habitat Types by Spatial Coverage.

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Chambers Island	Deep-water bedrock seascapes	1.63	51.70	51.70
	Sub-littoral bedrock seascapes	0.10	3.10	3.10
	Deep-water muddy seascapes	1.36	43.20	
	No multibeam data	0.05	1.70	
Total		3.15		54.80
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				



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 REV No. 0
 FIGURE No. 6

4.2.6 Ship Island

Ship Island is also located towards the inland region of Placentia Bay (Figure 1), in the northwestern region of the Merasheen BMA. This site ranges in depth from 41 m in the northwestern-most corner of the lease area to 223 m in the southeastern-most corner of the lease area (Figure 7). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (61.40%) seascape type is **deep-water muddy** (Table 7). This habitat type represents the eastern half of the lease area and extends upwards along the central and northern regions of the lease area an additional small section near the southwestern corner (Figure 7).

The hard-bottom region of this lease area is predominantly deep-water bedrock seascape (36.90%).. This seascape type spans across the western half of the lease area adjacent to the deep-water muddy seascape (Figure 7).

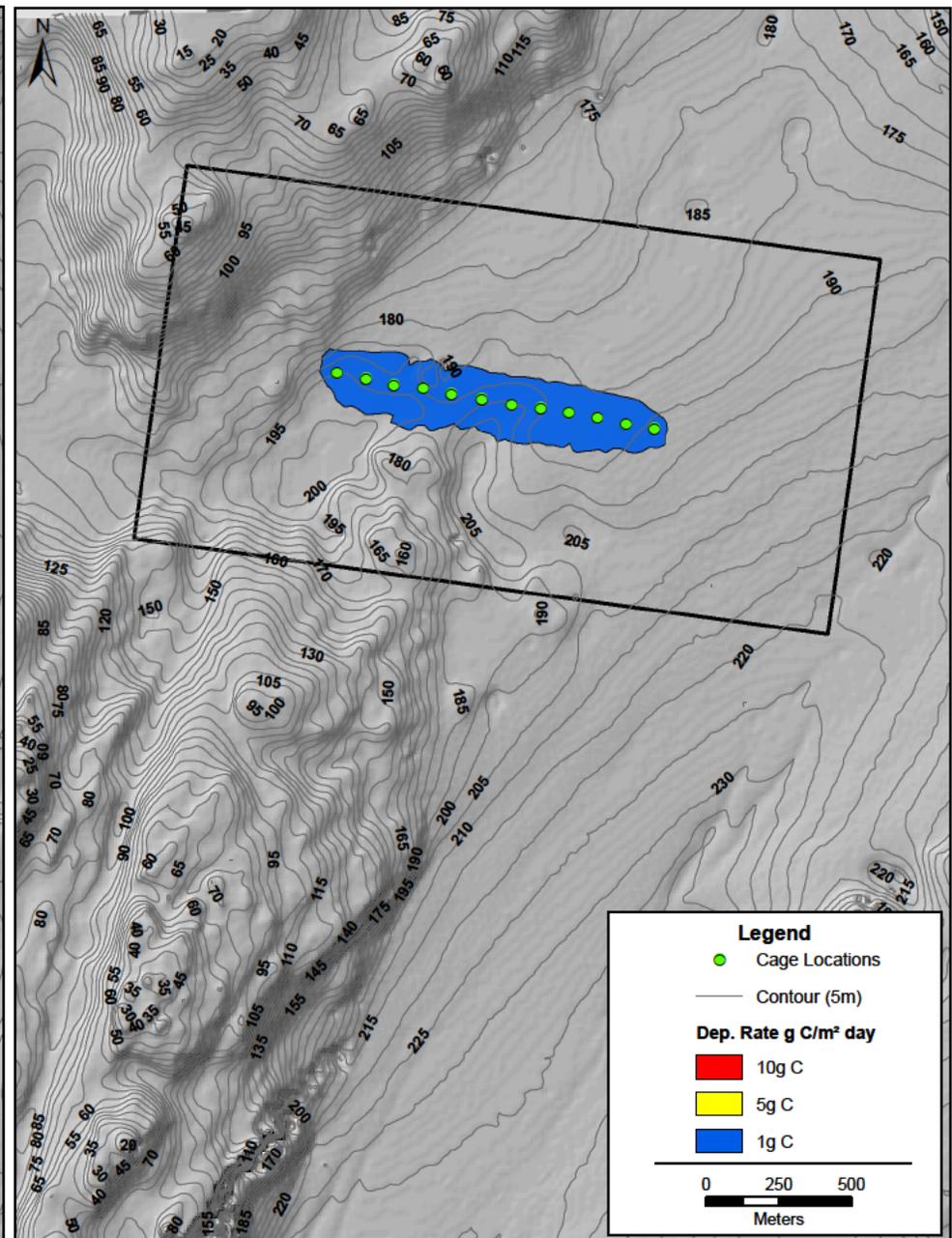
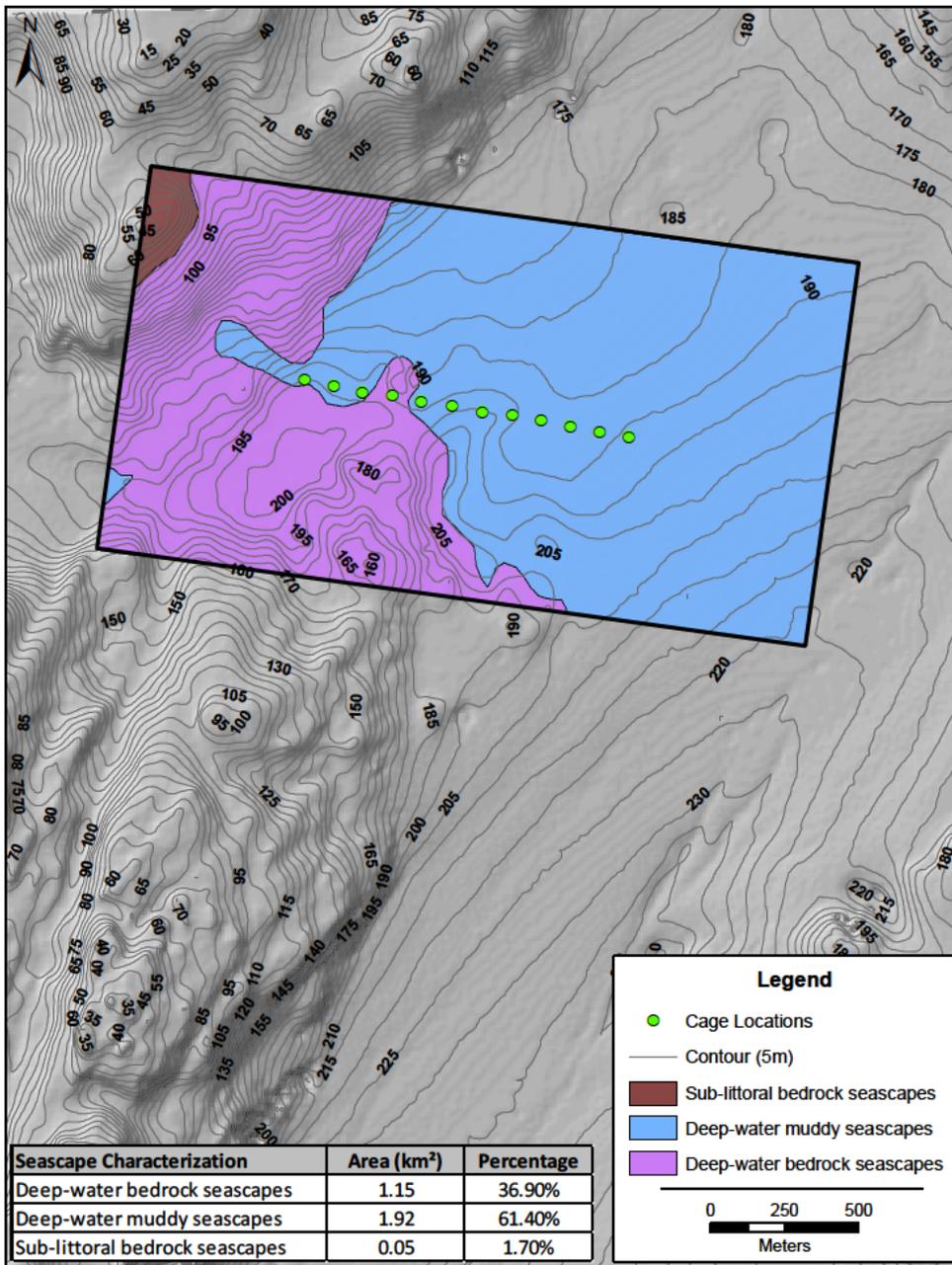
The remaining hard-bottom area of the lease site (1.70%) is **sub-littoral bedrock** seascape. This habitat type is confined to the northwestern corner of the proposed Ship Island lease area and ascends steeply towards the nearest small island (Figures 1 and 7).

Overall, the majority (61.40%) of the Ship Island lease area is soft-bottom (Table 7) and the 1 g depositional contour is predominantly over deep-water muddy seascape with some bedrock overlap (Figure 7).

Table 7 Summary of Ship Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Ship Island	Deep-water bedrock seascapes	1.15	36.90	36.90
	Sub-littoral bedrock seascapes	0.05	1.70	1.70
	Deep-water muddy seascapes	1.92	61.40	
Total		3.13		38.50

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)



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 FIGURE No. 7

4.2.7 Butler Island

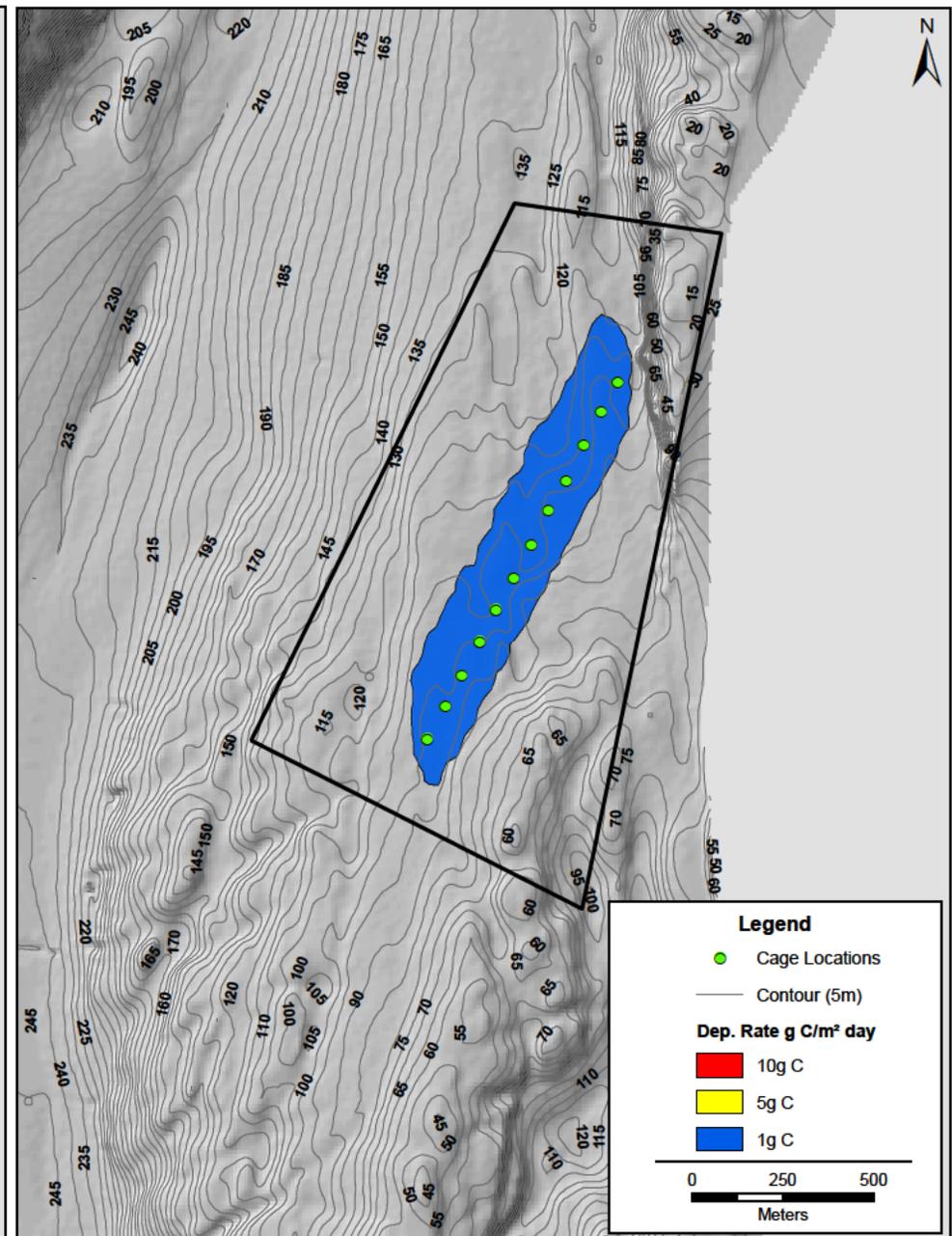
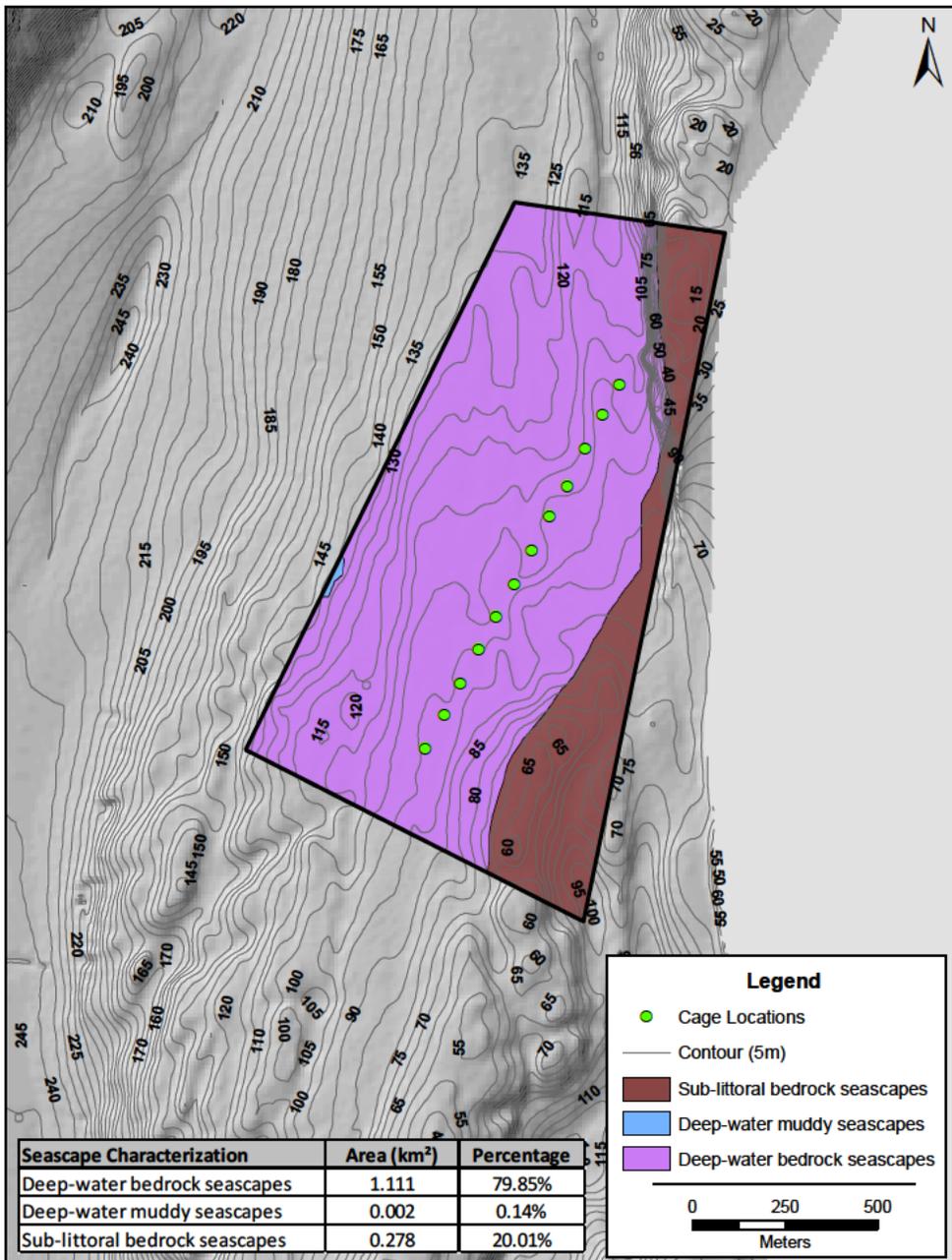
Butler Island is also located towards the inland region of Placentia Bay (Figure 1), in the northwestern region of the Red Island BMA. This site ranges in depth from 10 m in the northeastern-most corner of the lease area to 143 m along the southwestern perimeter of the lease area (Figure 8). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (79.90%) seascape type is **deep-water bedrock** (Table 8). This habitat type represents almost the entire western half of the lease area as well as the centre region of the eastern half (Figure 8).

The predominant hard-bottom habitat type of this lease area is **deep-water bedrock** seascape (79.85%). This habitat type is located in the western half of the proposed lease area and ascends towards the coastal shoreline. The remaining 20.01% of the lease area that comprises hard-bottom is sub-littoral bedrock, this is confined to the northwest corner of the lease area nearest the coastal shoreline (Figure 8).

Overall, the majority (99.86%) of the Butler Island lease area is hard-bottom (Table 8) and the 1 g depositional contour is predominantly over this habitat type as well with some overlapping deep-water bedrock areas (Figure 8).

Table 8 Summary of Butler Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km ²)*	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification**
Butler Island	Deep-water bedrock seascapes	1.111	79.85	79.85
	Sub-littoral bedrock seascapes	0.278	20.01	20.01
	Deep-water muddy seascapes	0.002	0.14	
Total		1.39		99.86
*Three significant digits are shown to capture the portion of the lease area that is soft-bottom.				
**The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015);				



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FIGURE No. 8

4.2.8 Red Island

Red Island is located towards the central region of Placentia Bay (Figure 1), also in the northwestern region of the Red Island BMA. This site ranges in depth from 18 m along the western margin of the lease area to 250 m along the southeastern perimeter of the lease area (Figure 9). The entirety (100%) of this proposed lease site is represented by the multibeam survey data. The predominant (69.23%) seascape type is **deep-water bedrock** (Table 9). This habitat type represents the majority of the western half and central region of the lease area (Figure 9).

The remaining hard-bottom seascape of this lease area is sub-littoral bedrock (23.53%). This seascape type is largely confined along the Eastern slope section of the proposed lease area running parallel to the nearest shoreline. There is an additional small section of sub-littoral bedrock in the middle of the southern perimeter of the lease area nearest the coastal shoreline (Red Island) (Figure 9).

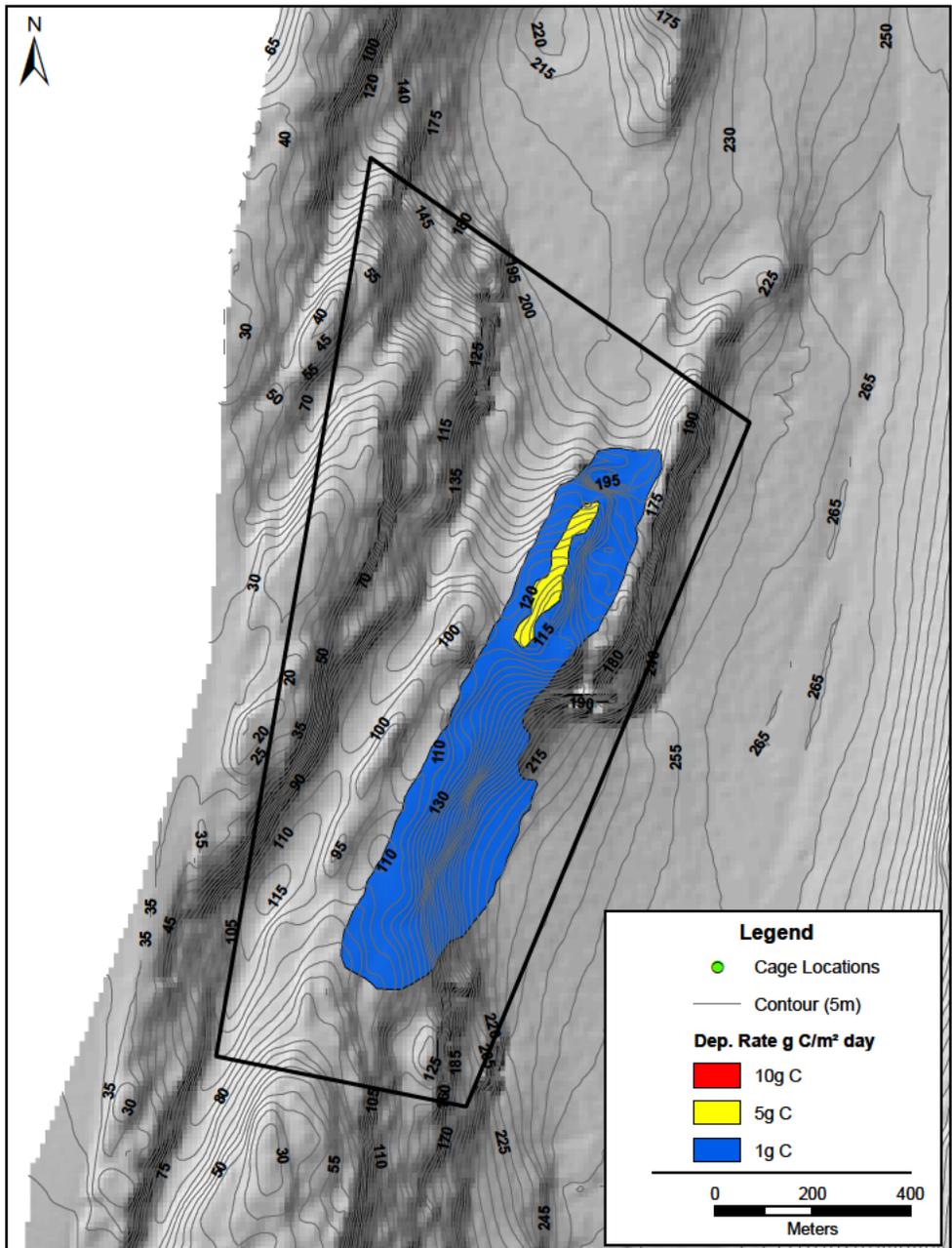
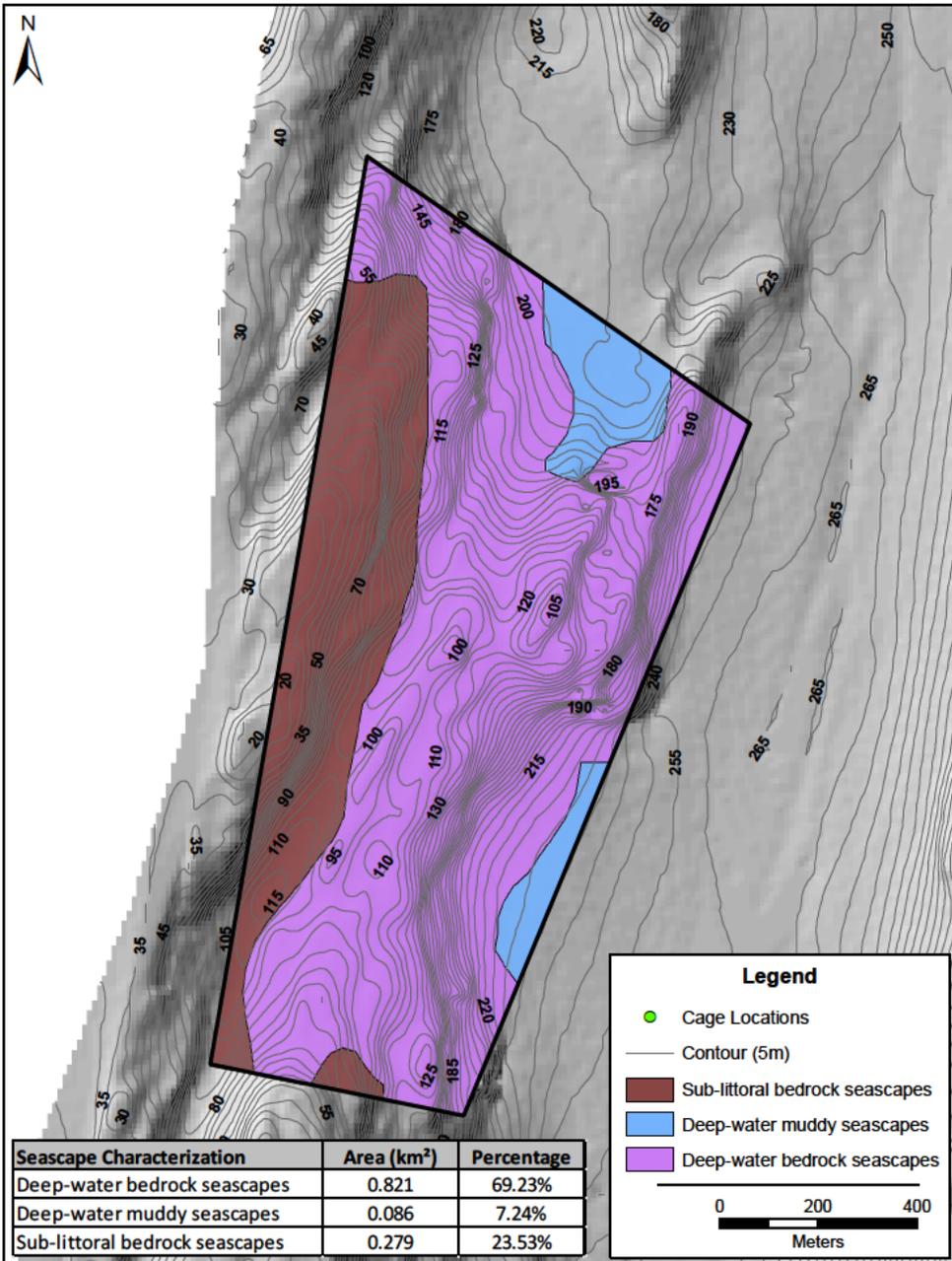
The soft-bottom habitat type of this lease area is **deep-water muddy** seascape (7.24%). This habitat type is located as two patches in the proposed lease area, one along the northern margin and a second along the southeastern boundary of the lease area.

Overall, the majority (92.76%) of the Red Island lease area is hard-bottom (Table 9) and the 1 g depositional contour is predominantly over deep-water bedrock habitat type (Figure 9).

Table 9 Summary of Red Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Red Island	Deep-water bedrock seascapes	0.821	69.23	69.23
	Sub-littoral bedrock seascapes	0.279	23.53	23.53
	Deep-water muddy seascapes	0.086	7.24	
Total				92.76

*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)



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 SCALE: 1:15,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION
 TITLE: SUB-LITTORAL SEASCAPE RED ISLAND

DATE: May 2017
 PROJECT No. TF1791503
 REV No. 0
 FIGURE No. 9

4.2.9 Darby Harbour

Darby Harbour is located centrally in Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 16 m in the centre of the northeastern margin of the lease area to 147 m in the southwestern region of the lease area (Figure 10). The majority (93.27%) of this proposed lease site is represented by the multibeam survey data. The predominant (35.80%) seascape type is **sub-littoral bedrock** (Table 10). This habitat type nearly encircles the lease area around the west, north and eastern regions representing the site location in proximity island shorelines in each of these areas (Figure 1).

In almost equal proportion, the remaining hard-bottom region of this lease area seascape is **deep-water bedrock** (34.80%). This habitat type extends from the northernmost corner towards the southeastern region of the lease area and also represents to easternmost corner of the lease area (Figure 10).

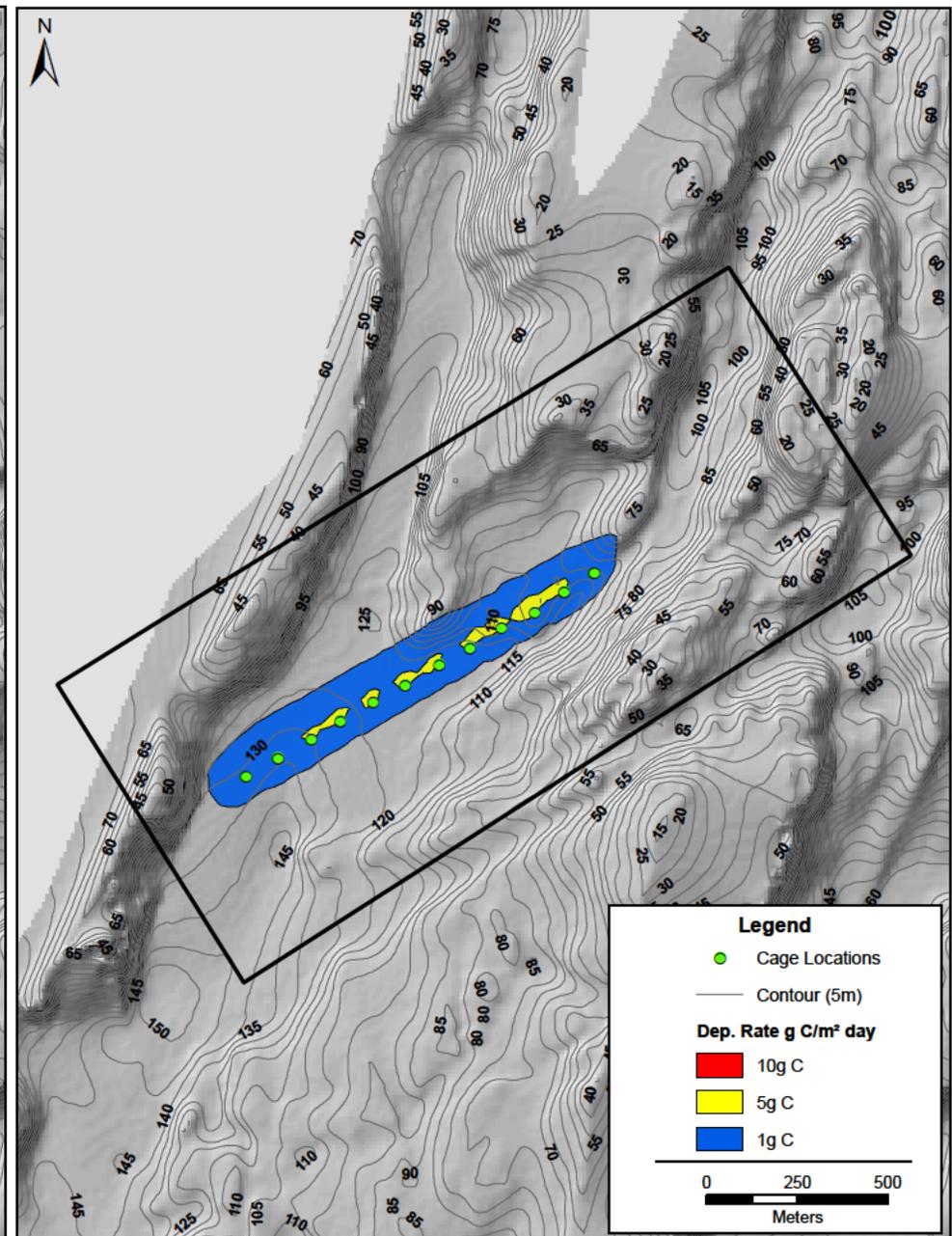
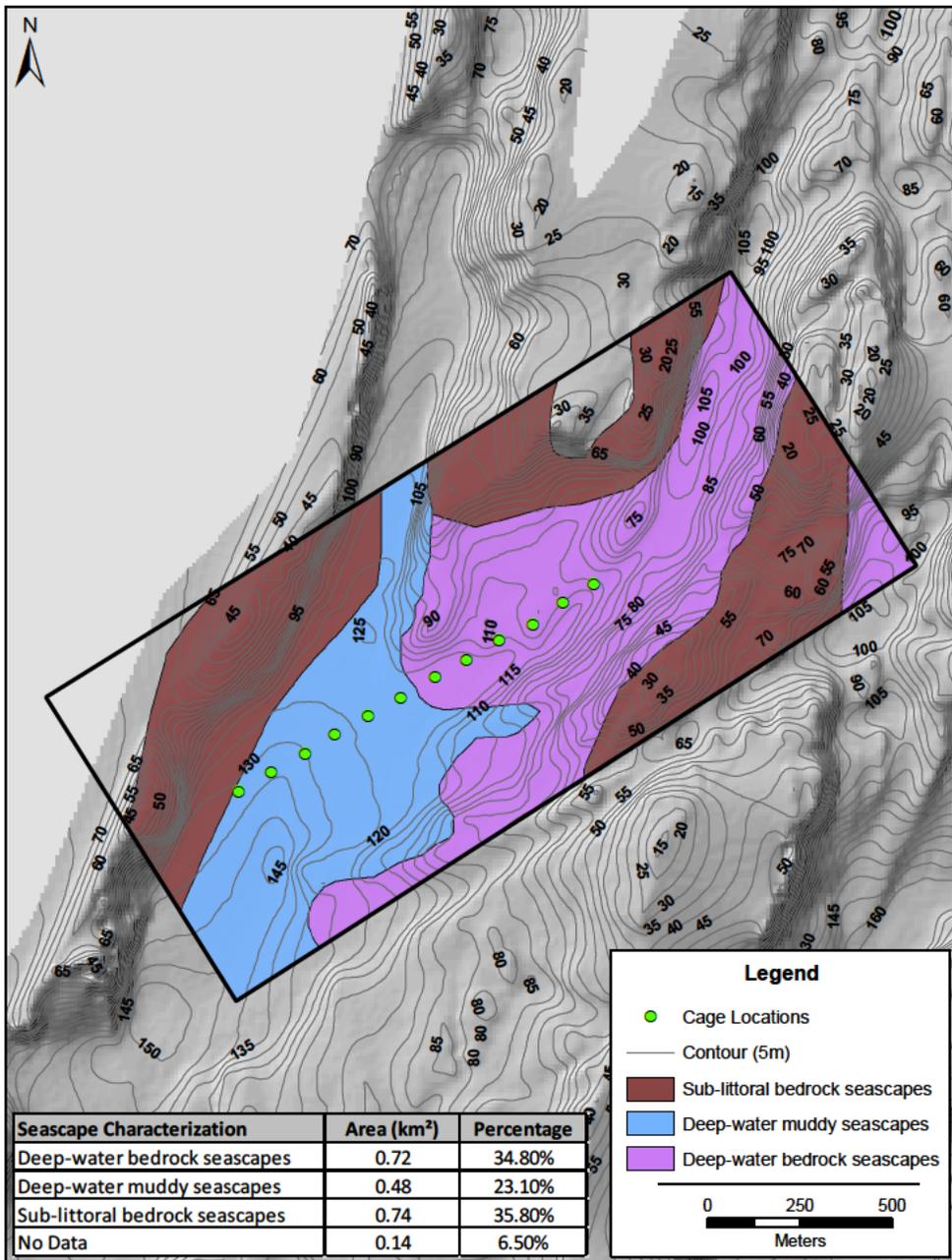
The soft-bottom area of the lease site (23.10%) is **deep-water muddy** seascape. This seascape type transverses north to south in the mid-section of the proposed lease site.

The remaining 6.50% of the Darby Harbour lease area is not represented by multibeam survey data. This is distributed in two regions of the lease site, in the northwestern region and the southwestern corner and both areas are in proximity to island shorelines.

Overall, the majority (70.60%) of the Darby Harbour lease area is hard-bottom (Table 10) and the 1 g depositional contour is predominantly over both deep-water bedrock and deep-water muddy seascapes (Figure 10).

Table 10 Summary of Darby Harbour Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Darby Harbour	Deep-water bedrock seascapes	0.72	34.80	34.80
	Sub-littoral bedrock seascapes	0.74	35.80	35.80
	Deep-water muddy seascapes	0.48	23.10	
	No multibeam data	0.14	6.50	
Total				70.60
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				



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 TITLE: SUB-LITTORAL SEASCAPE DARBY HARBOUR

DATE: May 2017
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 REV No. 0
 FIGURE No. 10

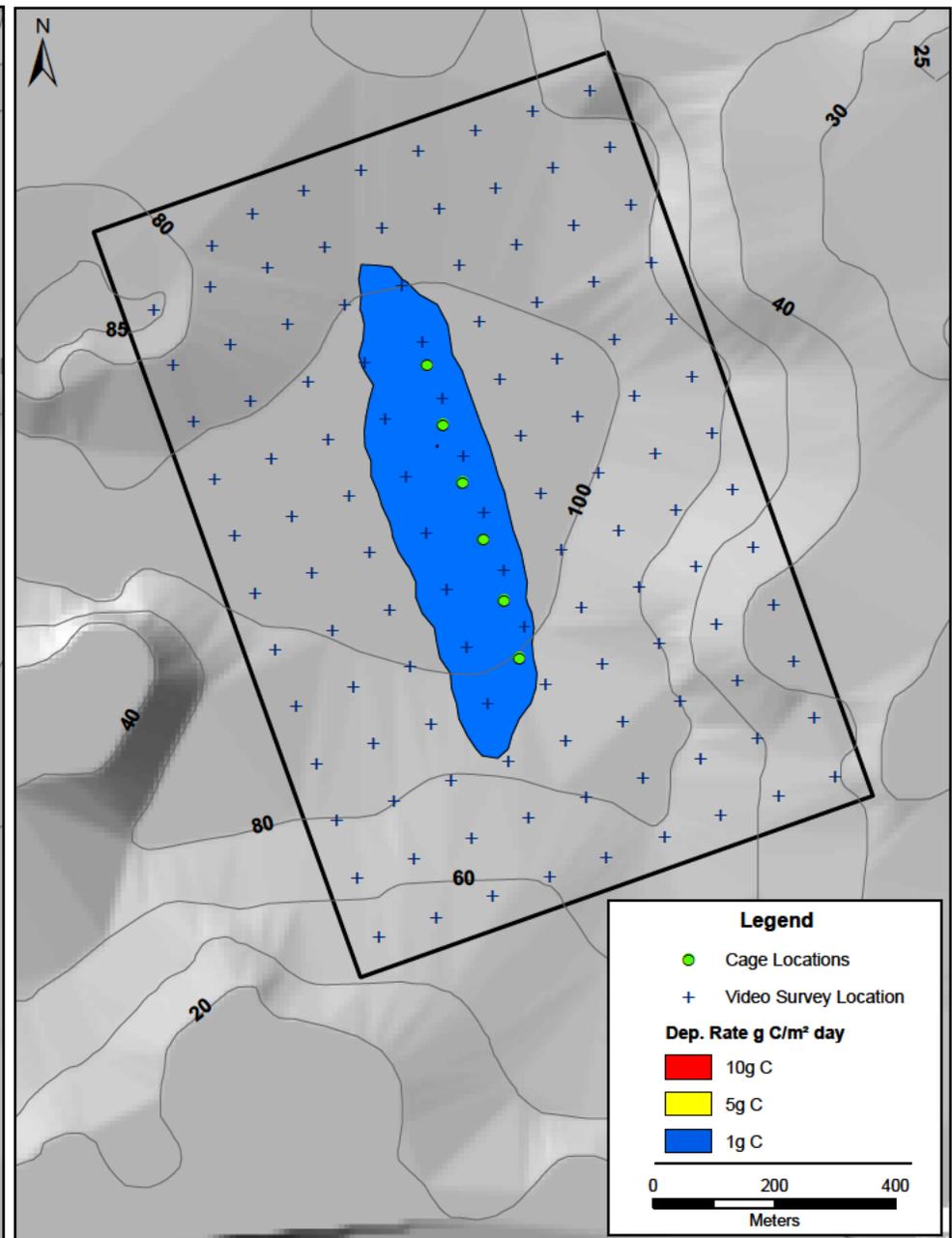
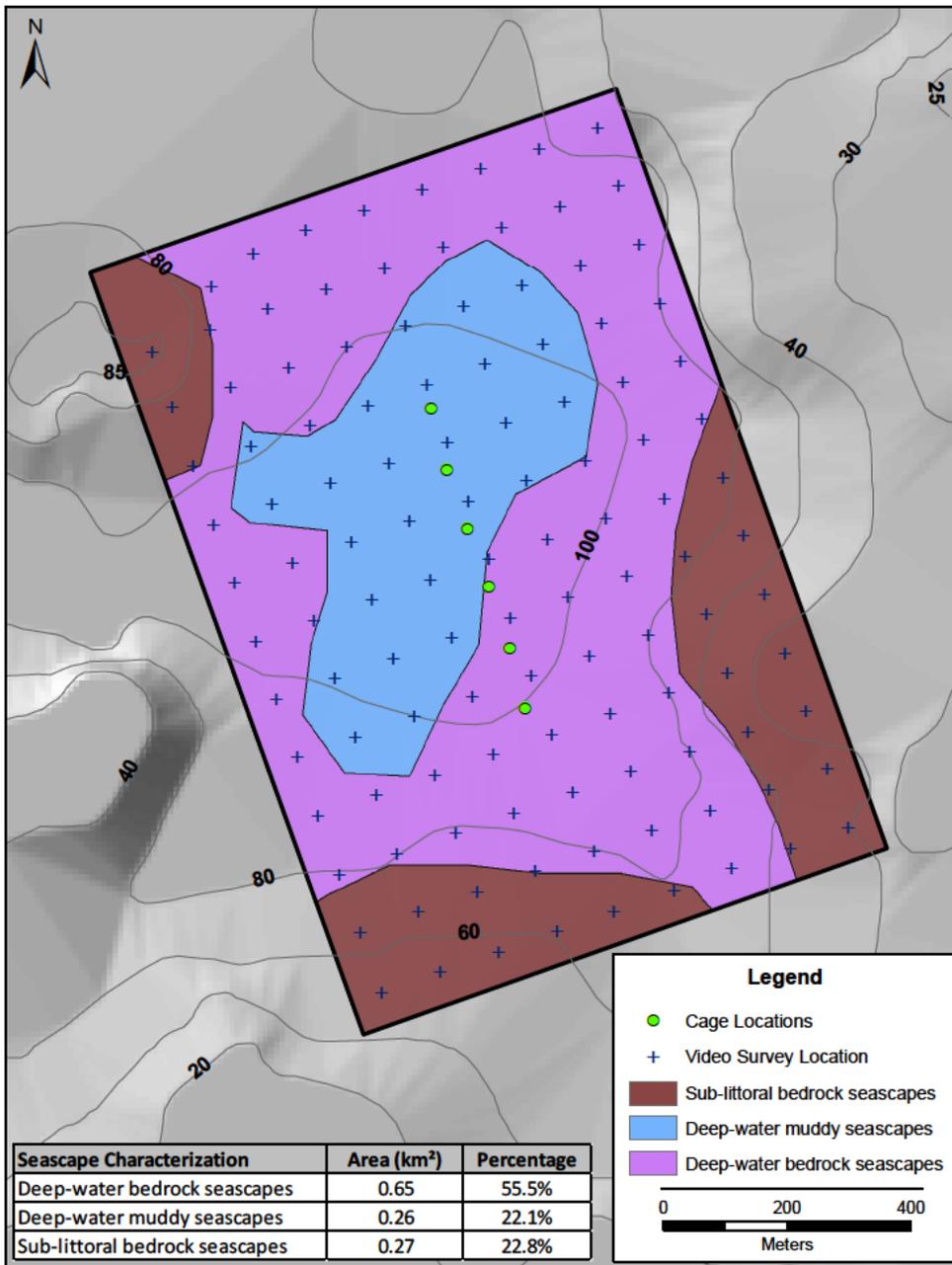
4.2.10 Brine Island

Brine Island is located in the southeast region of Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 40 m in the southeast region of the lease area to 100 m in the centre of the lease area (Figure 11). Only a portion (1.71%) of this proposed lease site is represented by the multibeam survey data, however it is represented by seascape characterization (identifying areas according to their habitat types). According to which, the predominant habitat type (55.5%) of this this lease area is **deep-water bedrock** (Table 11). This habitat type spans across the majority of the Northern half as well as the central and western regions of this lease area (Figure 11). The remaining (22.8%) of hard-bottom areas are sub-littoral bedrock seascape bordering the southeast, southern and northwest corners of the lease area.

The soft-bottom area of this lease area is centralized in the north and western regions of the (Figure 11) and south of this is a region of deep-water bedrock. According to the seascape classification alone, the majority (78.3%) is hard-bottom and the 1 g depositional contour spans both deep-water hard and soft bottom areas. However, as only lower resolution CHS benthic survey data was available for the bathymetry at this lease area, this characterization should be confirmed using conventional video survey at 100m grid intervals (video locations indicated in Figure 11). That survey information can be used to ground-truth the benthic characterization projection for this lease area (provided in a separate report from Grieg NL).

Table 11 Summary of Brine Island Benthic Habitat Types by Spatial Coverage According to Seascapes Characterization.

Proposed Marine Site	Seascape Characterization	Area (km ²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Brine Island	Deep-water bedrock seascapes	0.65	55.5	55.5
	Sub-littoral bedrock seascapes	0.27	22.8	22.8
	Deep-water muddy seascapes	0.28	22.1	
	No multibeam data	0.02	98.29	
Total				78.3**
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015);				
**Based on seascape characterization map and not multibeam survey area.				



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PROJECT: **BENTHIC SEASCAPE CHARACTERIZATION**

TITLE: **SUB-LITTORAL SEASCAPE BRINE ISLAND**

DATE: May 2017

PROJECT No. TF1791503

REV No. 0

FIGURE No. 1

4.2.11 Iona Islands

The Iona Islands lease area is located near the southeast coast of Placentia Bay (Figure 1), in the Red Island BMA. This site ranges in depth from 54 m in the eastern most corner of the of the lease area to 108 m in the northwest corner of the lease area (Figure 12). The majority (95.45%) of this proposed lease site is represented by the multibeam survey data. The predominant (70.20%) seascape type is deep-water **bedrock** (Table 12), this represents the only hard-bottom type in this lease area and covers the majority of the western and southern regions of this lease area (Figure 12).

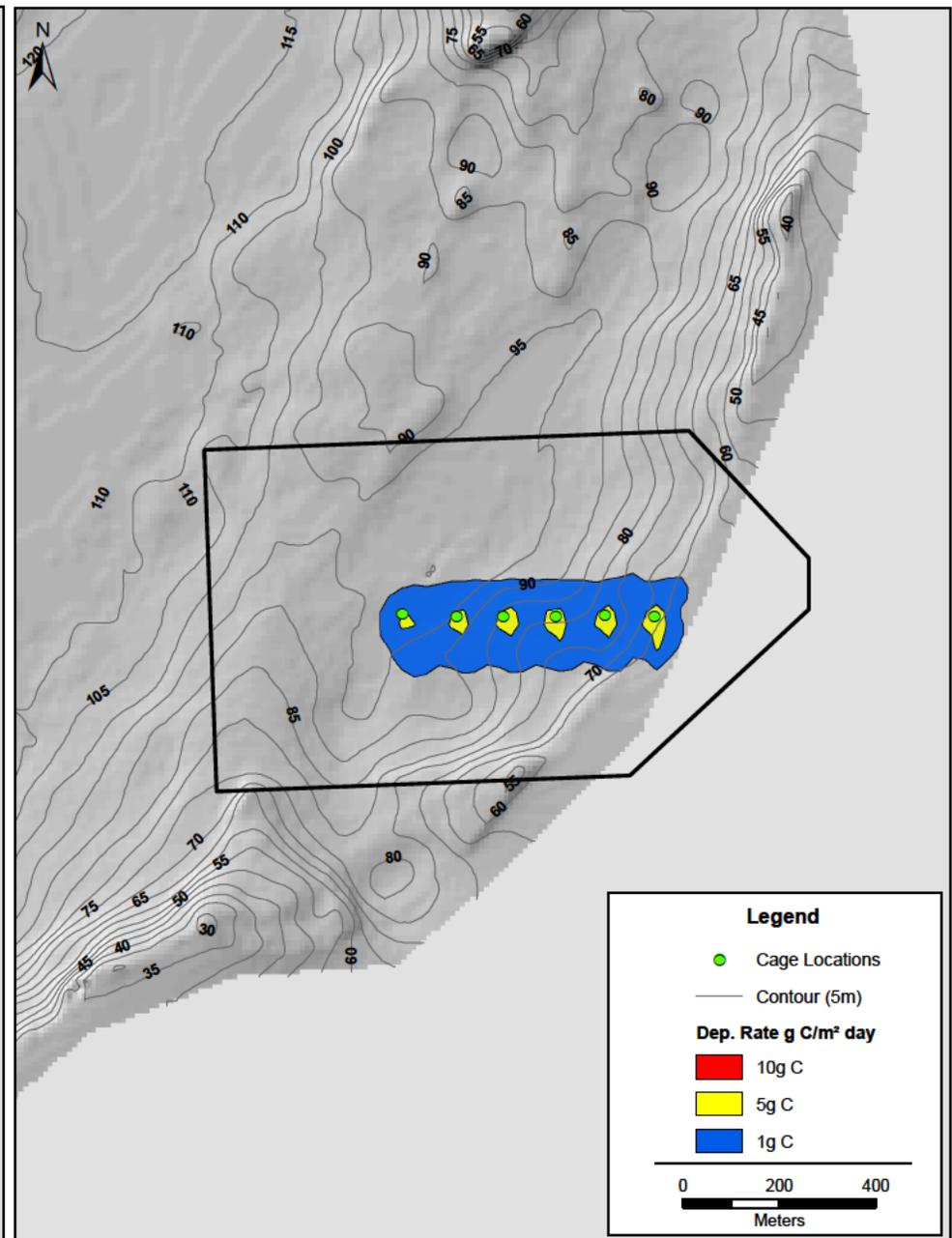
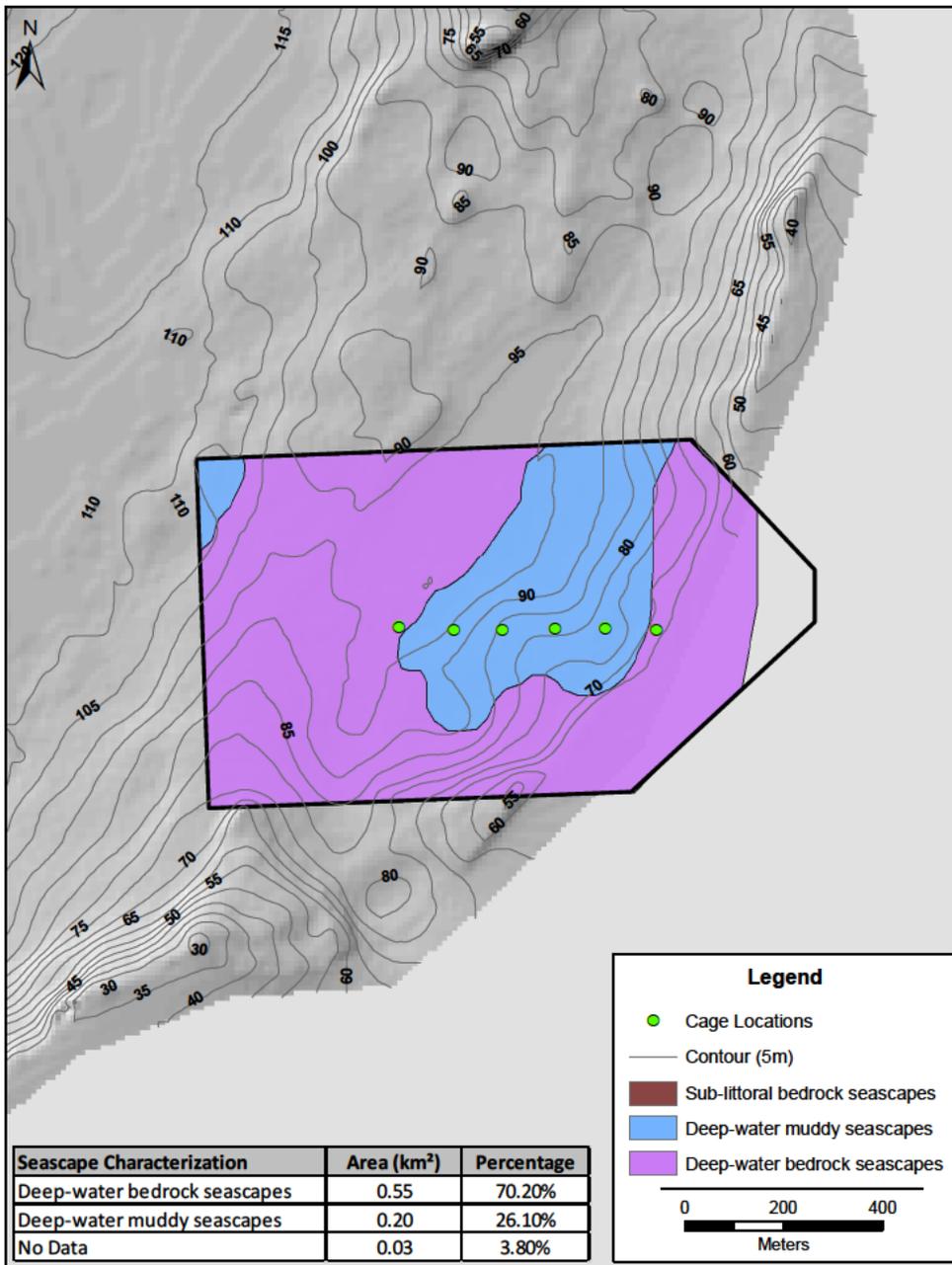
The soft-bottom area of the lease site (26.10%) is **deep-water muddy** seascape. This seascape extends from the northeast region of the lease area to the centre with an additional soft-bottom area in the northwest corner of the lease area (Figure 12).

The remaining 3.80% of the Iona Islands lease area is not represented by multibeam survey data. This is localized in the easternmost corner of the lease area projecting towards the adjacent shoreline.

Overall, the majority (70.20%) of the Iona Islands lease area is hard-bottom (Table 12) and the 1 g depositional contour is predominantly over deep-water muddy with some overlap of boon deep-water bedrock and seascapes (Figure 12).

Table 12 Summary of Iona Island Benthic Habitat Types by Spatial Coverage

Proposed Marine Site	Seascape Characterization	Area (km²)	Percentage of Lease Area	Percentage of Lease Area as Hard bottom Classification*
Iona Island	Deep-water bedrock seascapes	0.55	70.20	70.20
	Sub-littoral bedrock seascapes	0.00	0.00	
	Deep-water muddy seascapes	0.20	26.10	
	No multibeam data	0.03	3.80	
Total				70.20
*The AAR definition of hard bottom is “substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines.” (AAR, 2015)				



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 SCALE: 1:15,000

PROJECT: BENTHIC SEASCAPE CHARACTERIZATION

TITLE: SUB-LITTORAL SEASCAPE IONA ISLAND

DATE: May 2017

PROJECT No. TF1791503

REV No. 0

FIGURE No. 1

5.0 SUMMARY

The majority of Grieg NL's proposed marine production sites in Placentia Bay had more than 90% lease area represented by multibeam bathymetry and seascapes mapping (Table 1). Among these, 7 out of 8 sites are characterized as hard-bottom according to the AAR definition, only Ship Island appears to be a soft-bottom site. Although, only 69.34% of Long Island was surveyed, more than half this lease area is characterized as hard-bottom. Brine Island is tentatively characterized as hard-bottom, but requires evaluation of complimentary field survey data to confirm. Gallows Harbor had insufficient data and requires field survey results.

Table 13. Summary of Grieg NL Production Site Classification According to >50 of the Lease Area Being Characterized as Hard or Soft Bottom

Lease Area Name	Hard-Bottom	Soft-Bottom	Field Survey Required	Comments
Gallows Harbour				Insufficient spatial coverage
Long Island				69.34% multibeam coverage
Oderin Island				
Valens Island				
Chambers Island				
Ship Island				
Butler Island				
Red Island				
Darby Harbour				
Brine Island				Requires ground-truthing to confirm
Iona Islands				
*The AAR definition of hard bottom is "substrate consisting of bedrock, larger rocks/stones or fixed marine constructions such as wharfs, quays and pipelines." (AAR, 2015).				

Grieg NL Seafarms Ltd.

Application of Available Multibeam Acoustic and Seascapes Data to Map Proposed Marine Finfish Production Locations in Placentia Bay, Newfoundland (Final)

Amec Foster Wheeler Project #: TF1791503

16 June 2017

6.0 CLOSURE

Amec Foster Wheeler has prepared this benthic seascape characterization for Grieg NL Seafarms Ltd. as part of their Aquaculture Activities Regulations permitting requirements. Any questions associated with this report should be directed to the undersigned and we appreciate the opportunity to conduct this work on your behalf.

Yours sincerely,

**Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited**

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Grieg NL Seafarms Ltd.

Application of Available Multibeam Acoustic and Seascapes Data to Map Proposed Marine Finfish Production Locations in Placentia Bay, Newfoundland (Final)

Amec Foster Wheeler Project #: TF1791503

16 June 2017

7.0 REFERENCES

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Appendix A
Grieg NL Benthic Depositional Modeling Report

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FINAL

Benthic Depositional Modelling for Grieg Seafarms in Placentia Bay

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29 July 2016

Amec Foster Wheeler Project #: TF1691501



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EXECUTIVE SUMMARY

To address the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements condition 8.1a the 1, 5 and 10 grams of carbon per meter squared per day depositional contours are calculated for each marine production site using a specified daily quantity of feed usage. Overall the majority of depositional contours predicted from the model will not exceed 1g C/ m² /day with minimal exceptions at shallower sites.

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APPENDIX A: DHI HYDROGRAPHIC REPORT

1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler) is pleased to provide the required Benthic Depositional Modeling at the proposed marine production sites in Placentia Bay for the purpose of satisfying the federal Department of Fisheries and Oceans (DFO) Aquaculture Activities Regulations (AAR) permitting requirements specific to:

“Predicted Contours [AAR paragraph 8(1)(a)]

1. (1) Calculate the rate of deposition of biochemical oxygen demanding (BOD) matter from the facility during maximum daily quantity of feed usage, using an aquaculture waste deposition model, and map the 1, 5, and 10 g C/m²/day depositional contours.”

This work was conducted using the commercially available aquaculture industry benthic depositional modeling software DEPOMOD (version 2.4.1) (Cromey et al 2002) using the methods and settings defined in “DEPOMOD Canada Methods and Settings v1.6” and provided by DFO (DFO 2016), and the output calculations were plotted using MATLAB (version 7.12.0.635 R2011a) software.

2.0 INPUT DATA

Information regarding the locations and production capacity of Grieg NL Seafarms Ltd. marine sites was obtained from the “Placentia Bay Atlantic Salmon Aquaculture Project” Environmental Assessment Registration (Grieg NL 2016) and in consultation with Grieg NL Seafarms Ltd. personnel.

2.1 Bathymetry

A 2400x2400 m bathymetric grid was created around each farm site using data obtained from the Canadian Hydrographic service.

2.2 Currents

Current data was recorded at the 11 sites of interest during the winter of 2015-2016 by DHI (see Appendix A). The deployments ranged from ~12 hours to several days. The 20-minute averaged data was looped on itself to create 1-month long timeseries for each site.

Other assumptions used for setting up the current velocity data:

- ▶ ADCP moored ~3m above anchor (seafloor)
- ▶ No magnetic correction applied to raw data, we apply this inside DEPOMOD
- ▶ Use the same 3 depth layers defined in the DHI report (Appendix A)
- ▶ Mean tidal range is 1m above chart datum

2.3 DEPOMOD Inputs

Grid Generation Module (values set by user)	
Major grid cell dimensions	40 x 40 m
Number of major grid cells	60
Minor grid cell dimensions	25 x 25 m
Number of minor grid cells	90
Particle Tracking Module	
Material type	Carbon
Feed release type	Continuous release of food
<i>Particle Information (defaults)</i>	
Feed water content	9%
Feed digestibility	85%
Feed wasted as % of feed pellets (dry weight)	3%
Carbon as % of feed pellets (dry weight)	49%
Carbon as % of feces (dry weight)	30%
Settling velocity of feed pellets (mean)	9.5 cm/s
Settling velocity of feces (mean)	3.2 cm/s
<i>Current velocity data (see Appendix A for Current information)</i>	
Current velocity layers	3: near-surface, mid-depth, near-bottom

Grid Generation Module (values set by user)	
Current velocity time step	1200 s (20 minutes)
<i>Turbulence model (default values)</i>	
Random walk model	Yes
Dispersion coefficient (x)	0.100 m ² s ⁻¹
Dispersion coefficient (y)	0.100 m ² s ⁻¹
Dispersion coefficient (z)	0.001 m ² s ⁻¹
<i>Particle trajectory model (default values)</i>	
Number of particles released	10
Trajectory evaluation accuracy (model time step)	High (60 s)
<i>Resuspension module</i>	
	Turned off

2.4 CAGE INFORMATION

Number of Cages	12 per site (6 at Brine island and Iona island)
Cage Circumference	160 m
Cage diameter	51 m
Cage depth (below water surface)	30 m
Feed input	1,124 kg/cage/day

3.0 FARM SITE RESULTS

Below are the depth layers used, maps of the lease area, and depositional contours generated using DEPOMOD for 1, 5 and 10 grams of carbon per meter squared per day calculated for each marine production site based on the specified daily quantity of feed input. Depths depicted in all figures are in meters.

3.1 Gallows Harbour

Table 3-1: Gallows Harbour depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Gallows Harbour (47.3588N, 54.6942W)	113 m	Near-Surface	2159	20	83 m above bottom
		Mid-Depth	2159	20	43 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-1: Gallows Harbour Map

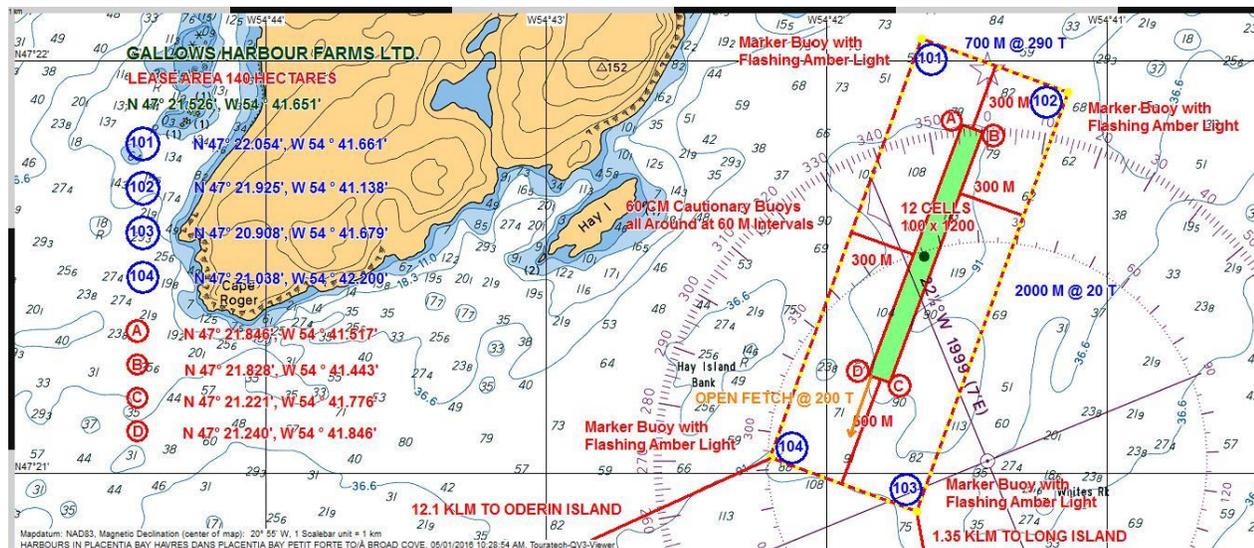
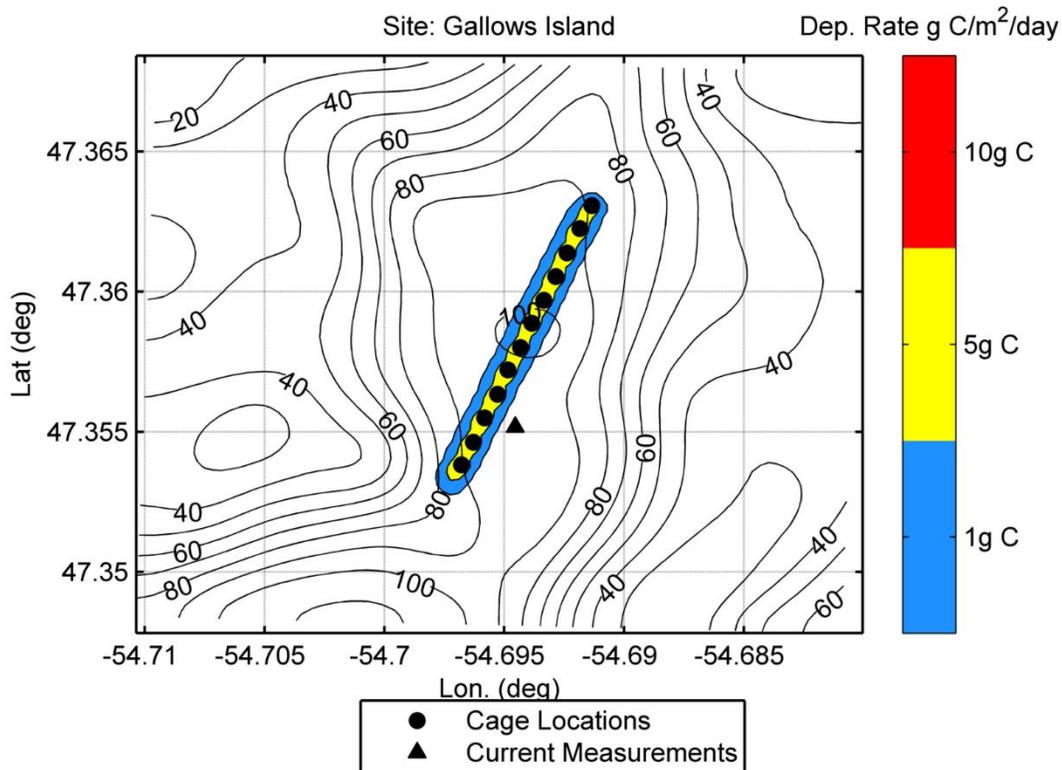


Figure 3-2: Gallows Harbour depositional contours



3.2 Long Island

Table 3-2: Long Island depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Long Island (47.3283N, 54.6979W)	137 m	Near-Surface	2159	20	107 m above bottom
		Mid-Depth	2159	20	50 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-3: Long Island map

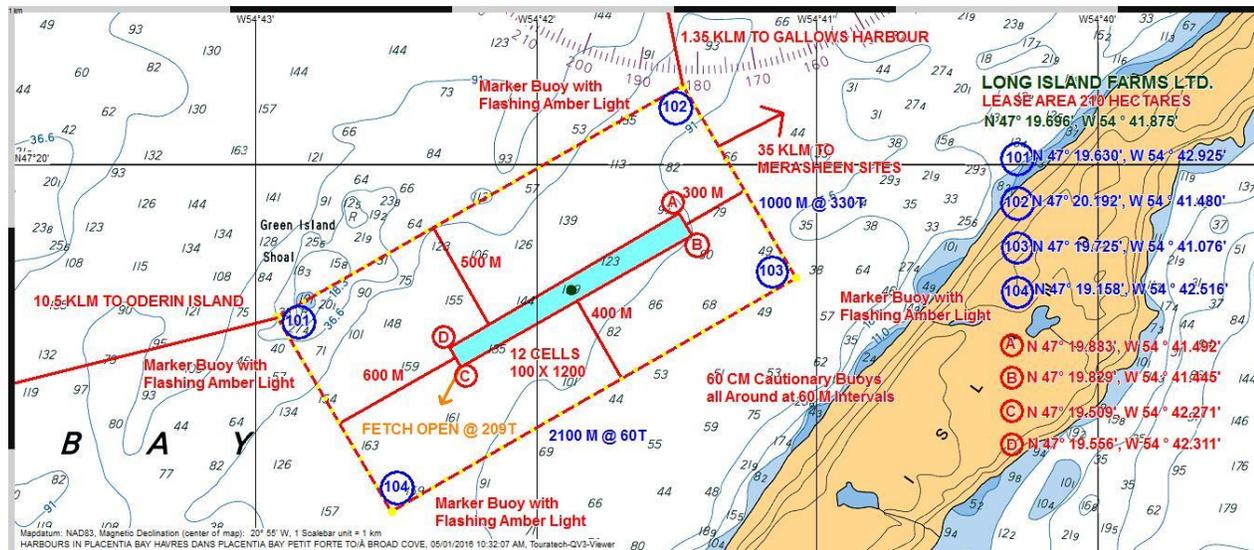
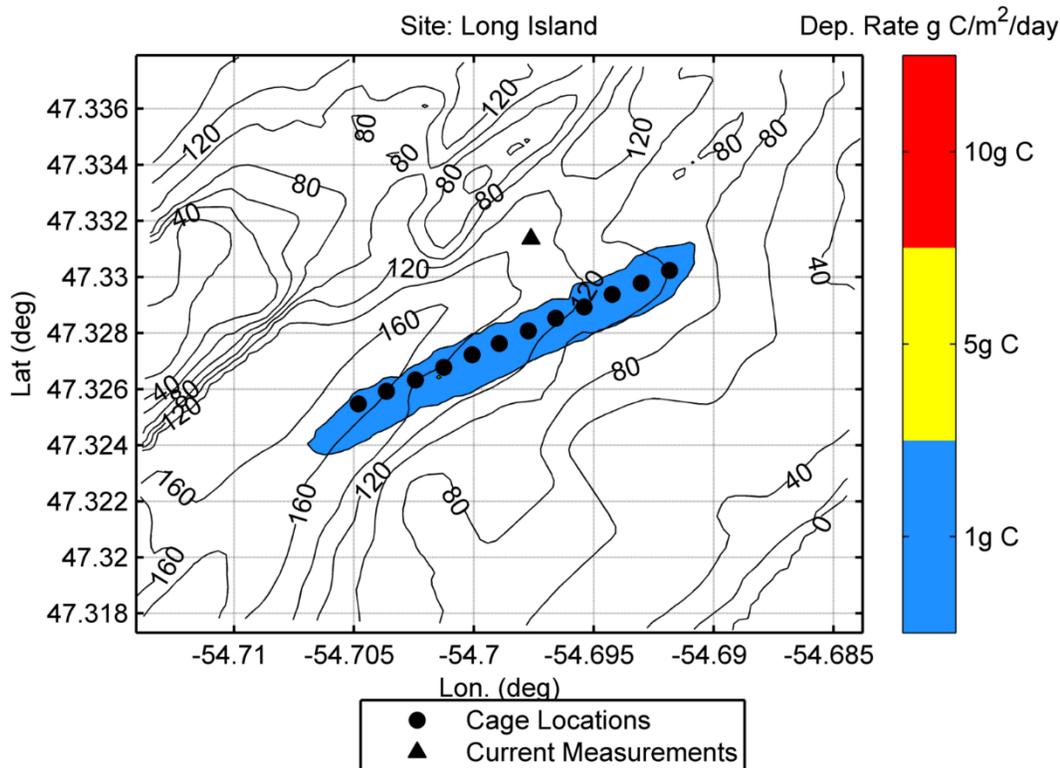


Figure 3-4: Long Island depositional contours



3.3 Oderin Island

Table 3-3: Oderin Island depth layer information

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Oderin Island (47.2983, 54.8595W)	83 m	Near-Surface	2159	20	53 m above bottom
		Mid-Depth	2159	20	25 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-5: Oderin Island map

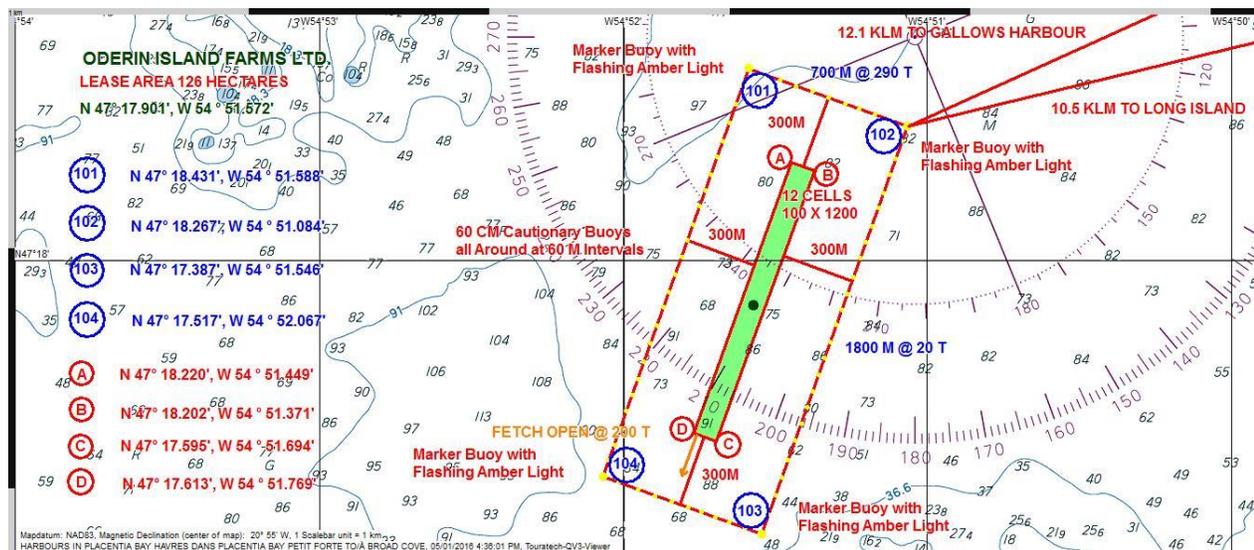
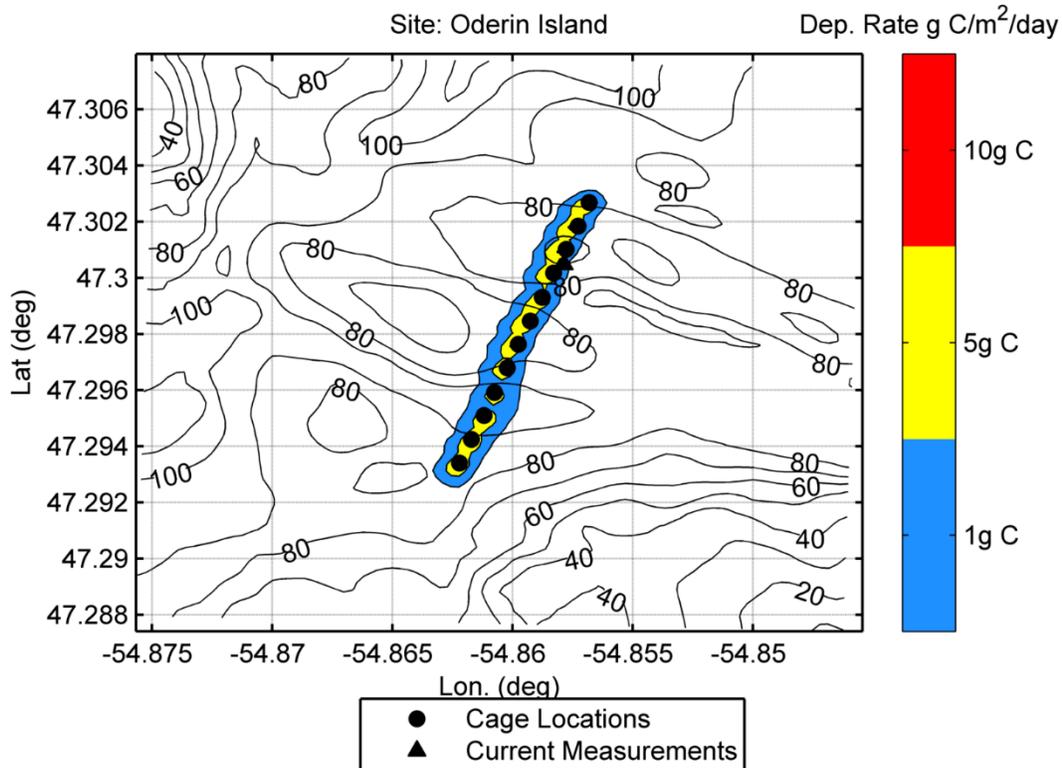


Figure 3-6: Oderin island depositional contours



3.4 Valens Island

Table 3-4: Valens Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Valens island (47.5243N, 54.3901W)	238 m	Near-Surface	2159	20	213 m above bottom
		Mid-Depth	2159	20	108 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-7: Valens Island map

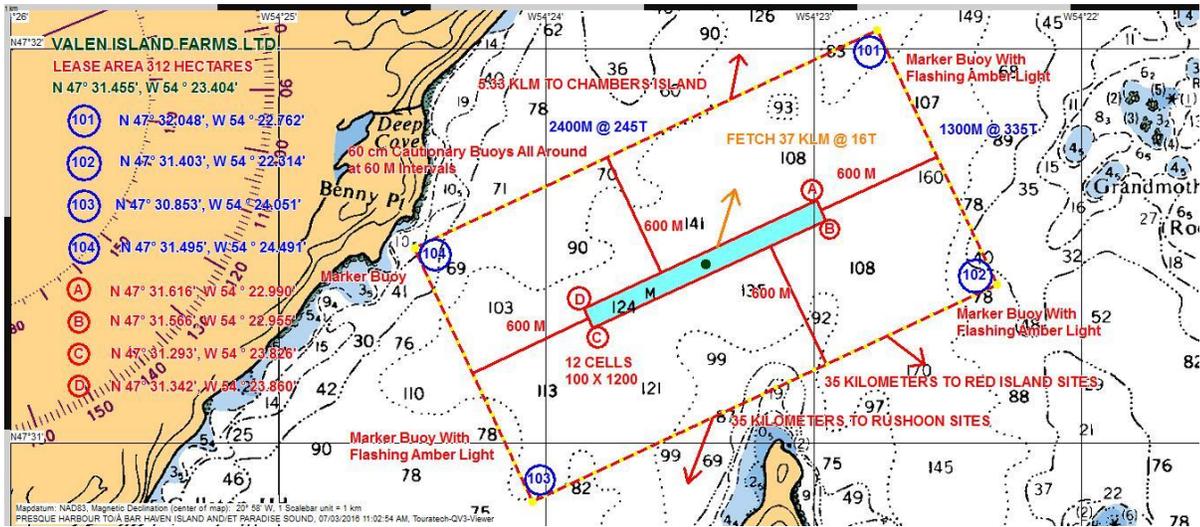
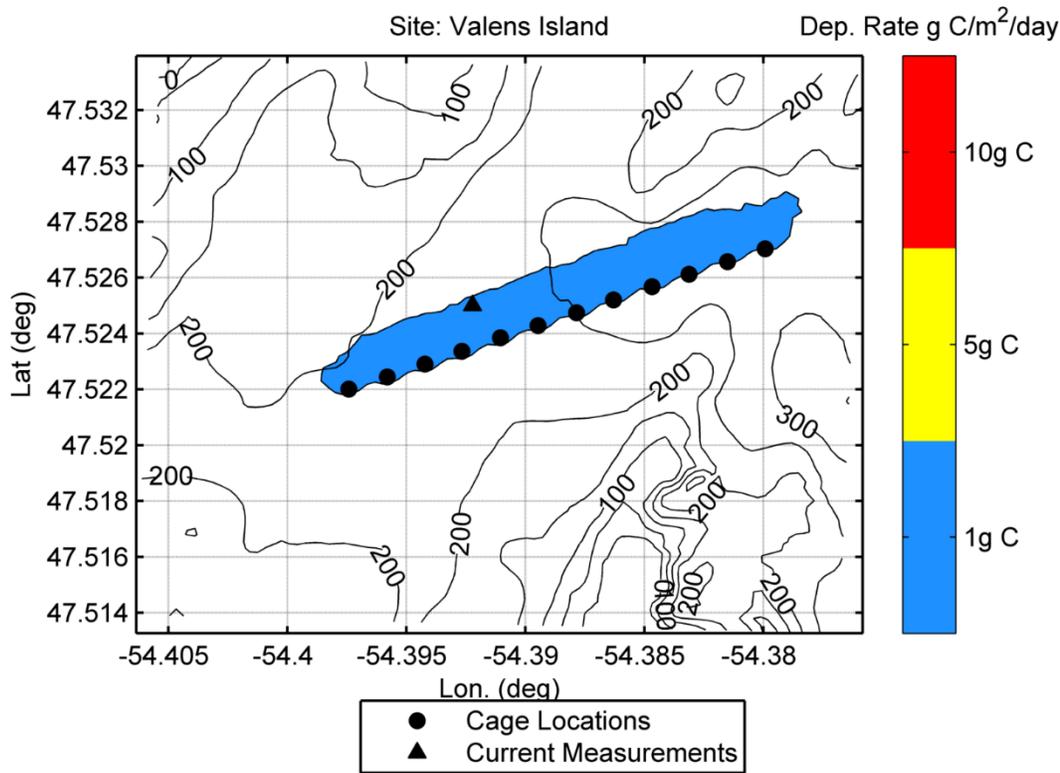


Figure 3-8: Valens Island depositional contours



3.5 Chambers Island

Table 3-5: Chambers Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Chambers Island (47.5795N, 54.3520W)	268 m	Near-Surface	2159	20	238 m above bottom
		Mid-Depth	2159	20	108 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-9: Chambers Island map

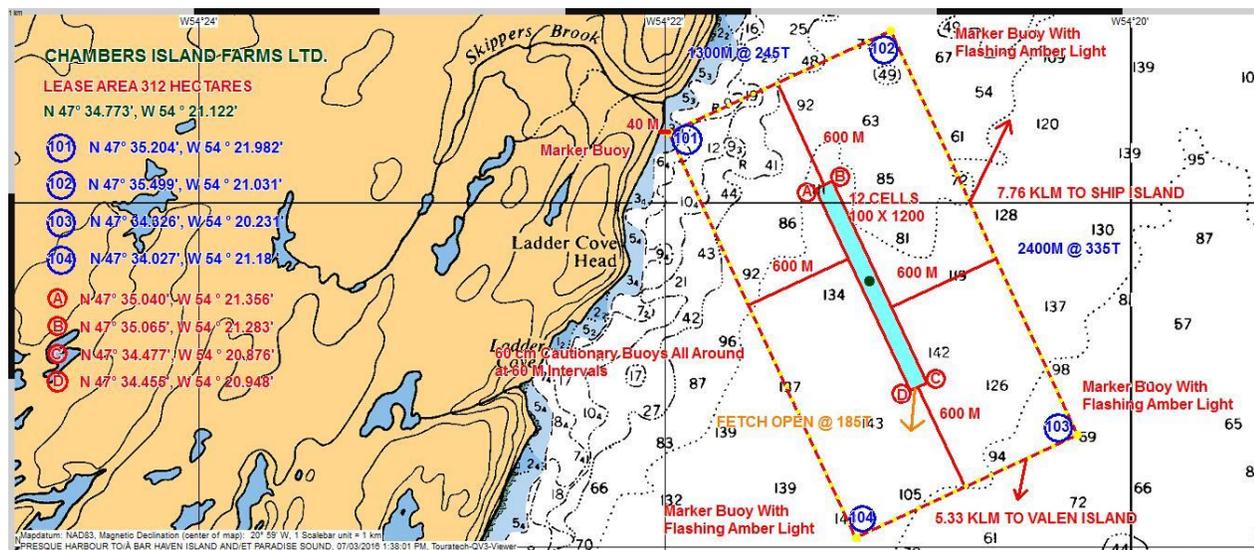
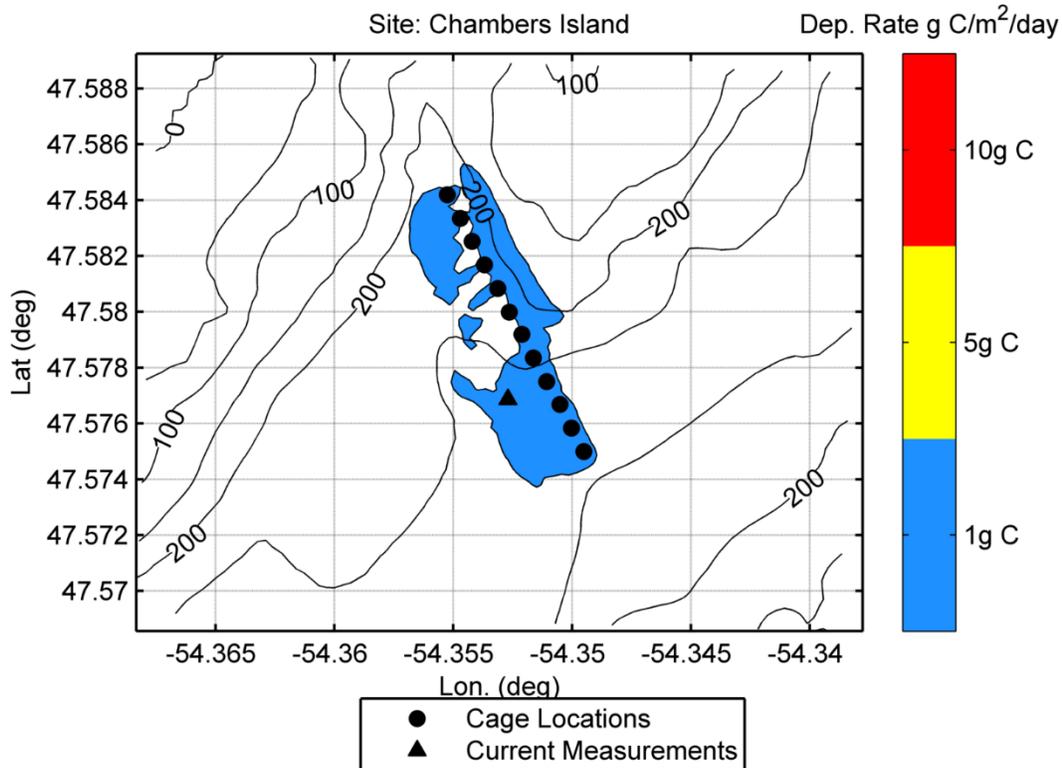


Figure 3-10: Chambers island depth contours



3.6 Ship Island

Table 3-6: Ship island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Ship Island (47.6490N, 54.2794W)	203 m	Near-Surface	2159	20	173 m above bottom
		Mid-Depth	2159	20	88 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-11: Ship Island map

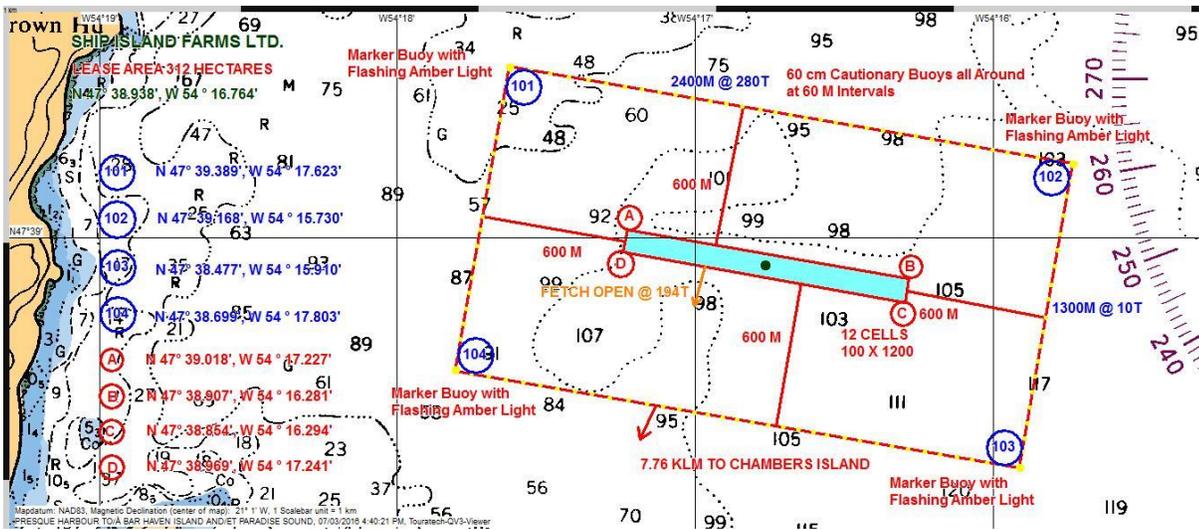
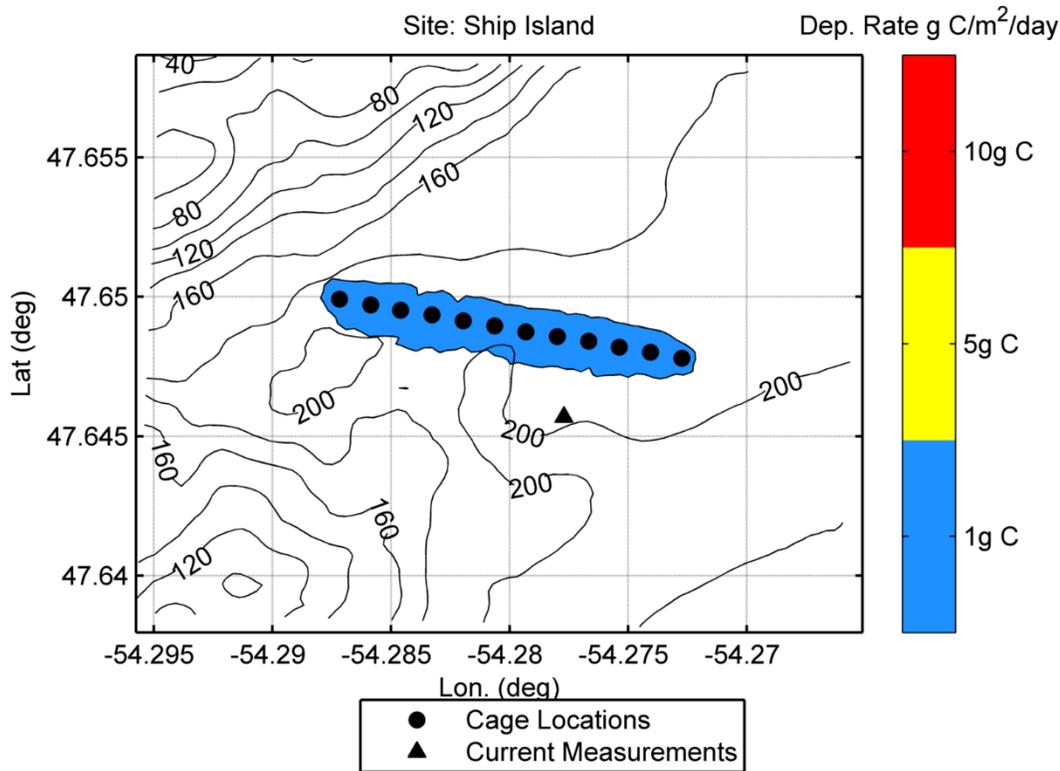


Figure 3-12: Ship Island depositional contours



3.7 Butler Island

Table 3-7: Butler Island depositional contours

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Butler Island (47.5700N, 54.1159W)	103 m	Near-Surface	2159	20	73 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-13: Butler Island map

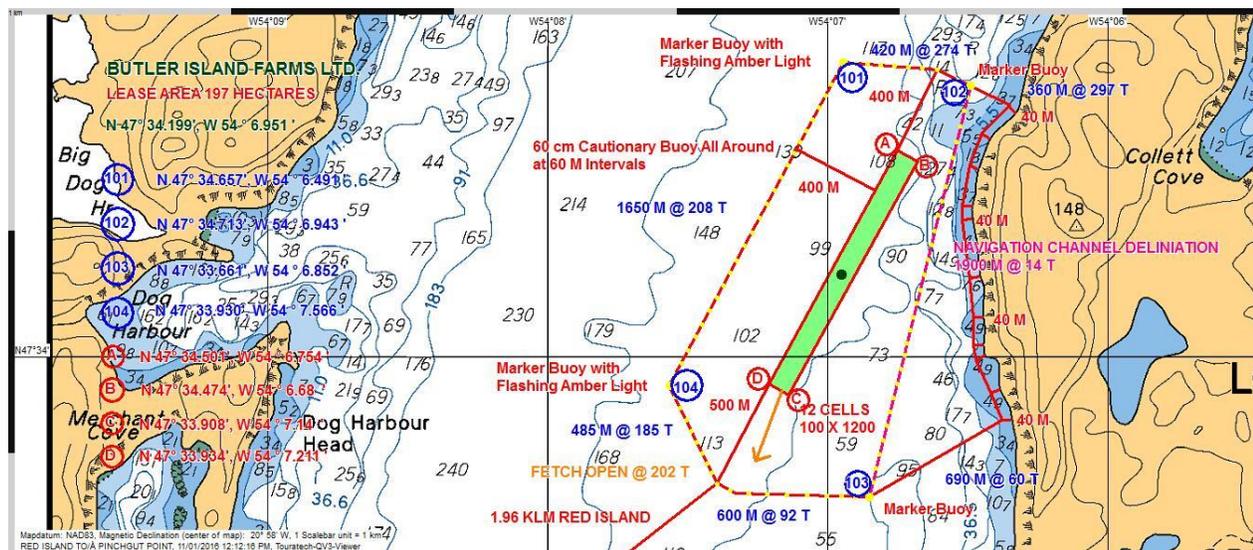
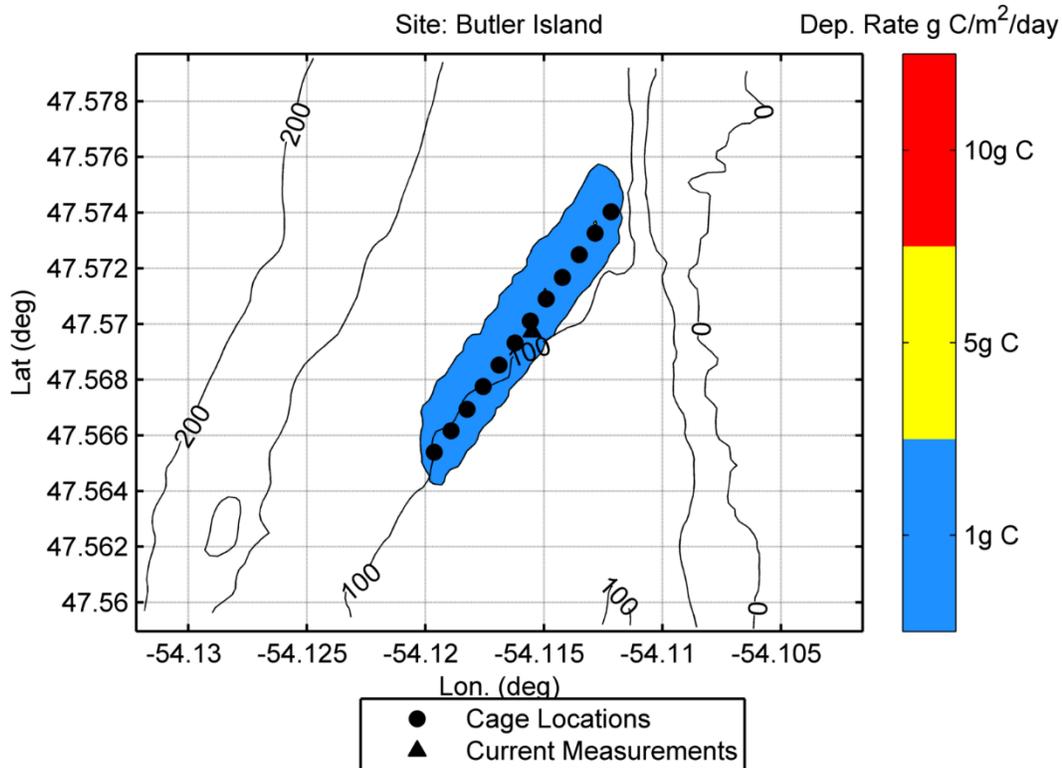


Figure 3-14: Butler Island depositional contours



3.8 Red Island

Table 3-8: Red Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Red Island (47.5404N, 54.1489W)	108 m	Near-Surface	2159	20	78 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-15: Red Island map

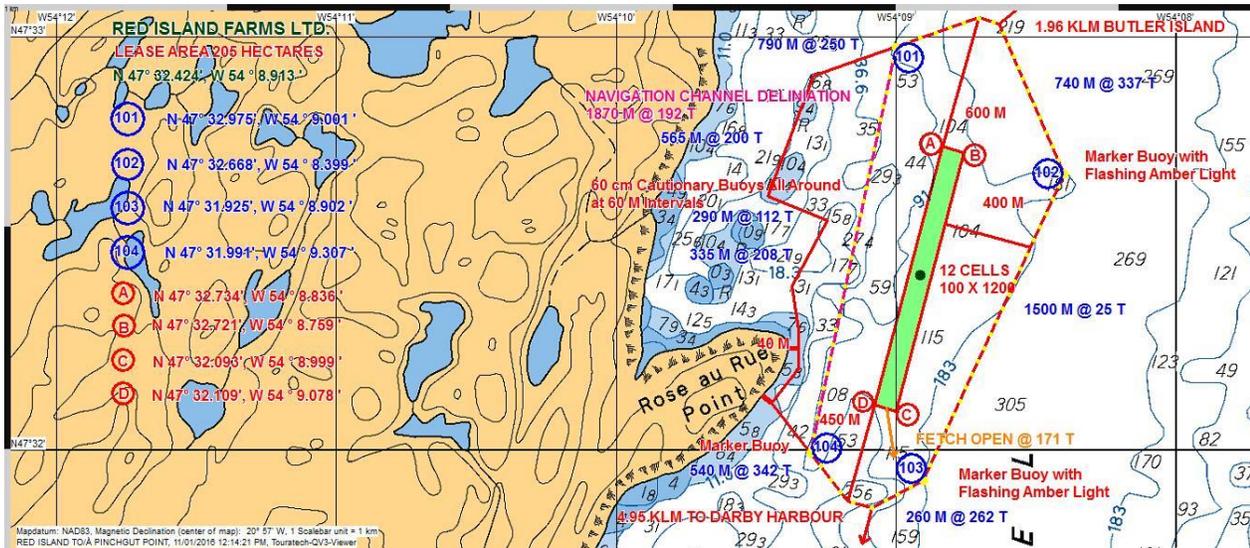
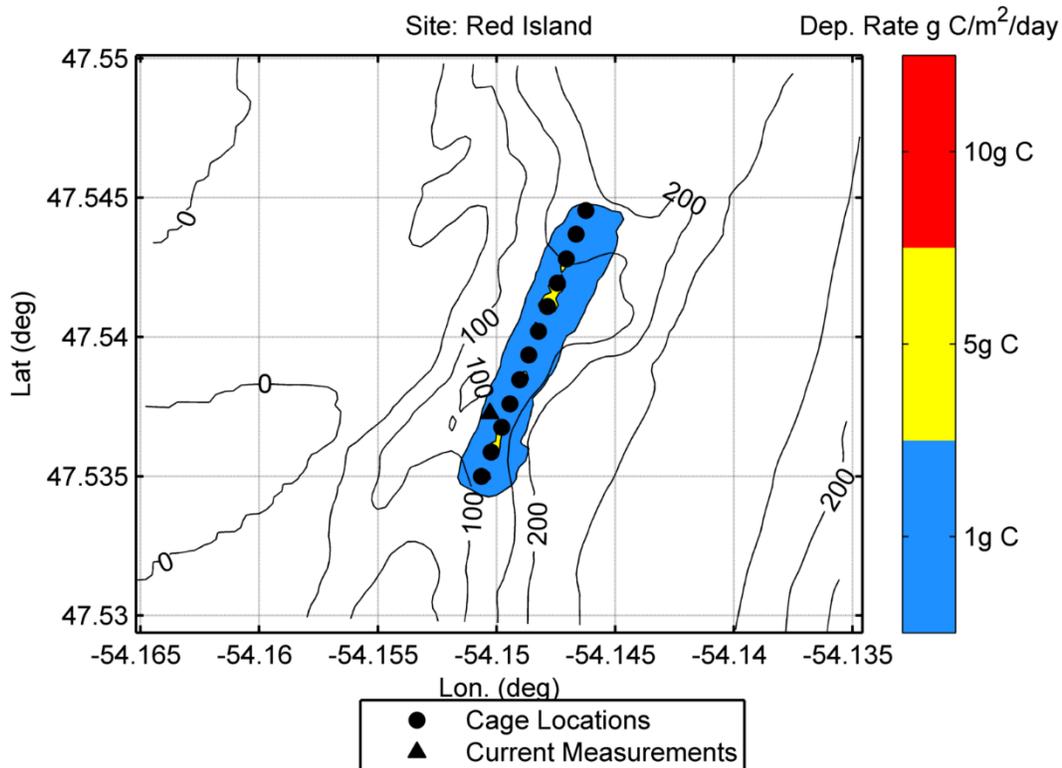


Figure 3-16: Red Island depositional contours



3.9 Darby Harbour

Table 3-9: Darby harbour depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Darby Harbour (47.4798N, 54.1863W)	125 m	Near-Surface	2159	20	95 m above bottom
		Mid-Depth	2159	20	45 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-17: Darby Harbour map

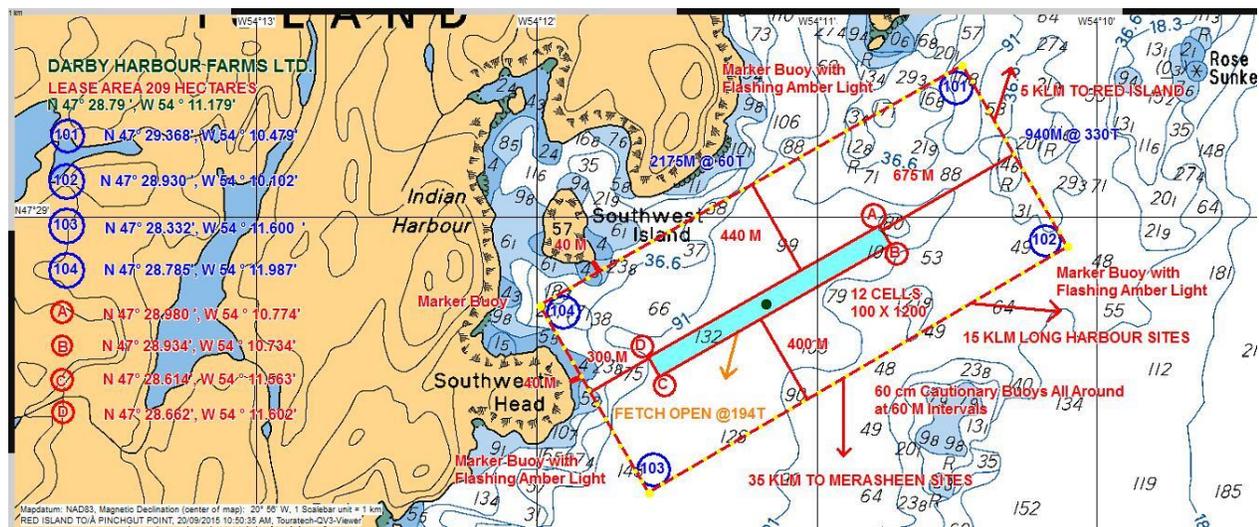
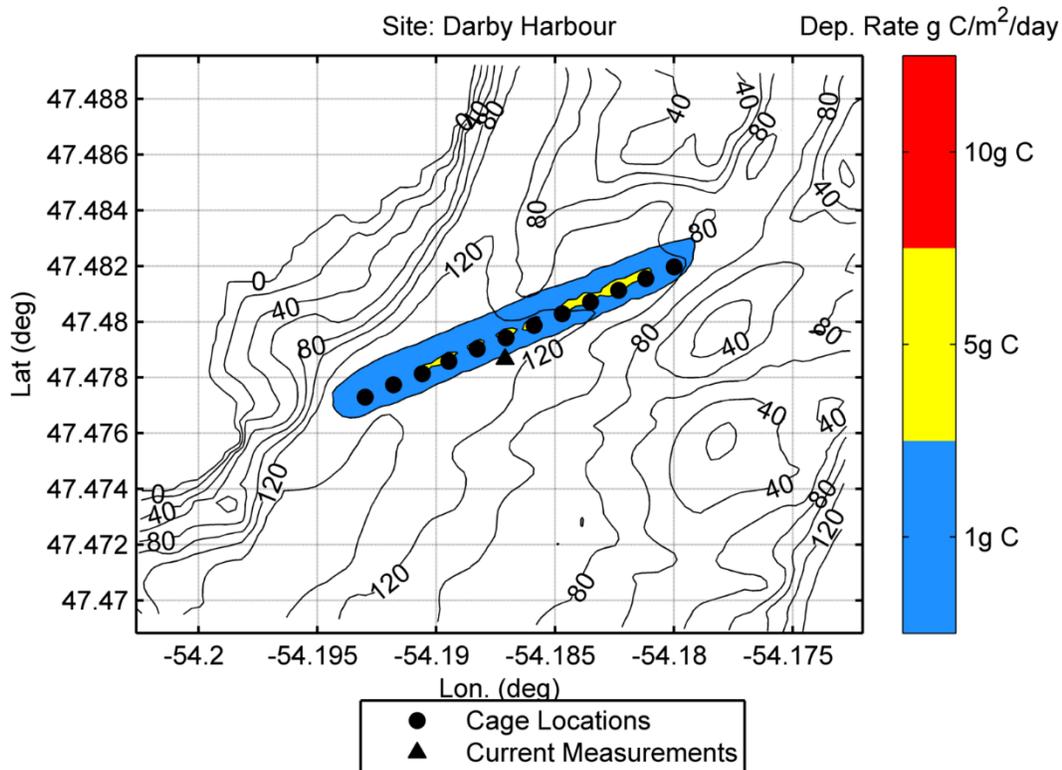


Figure 3-18: Darby Harbour depositional contours



3.10 Brine Islands

Table 3-10: Brine Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Brine Islands (47.4455N, 53.9671W)	118 m	Near-Surface	2159	20	88 m above bottom
		Mid-Depth	2159	20	42 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-19: Brine island map

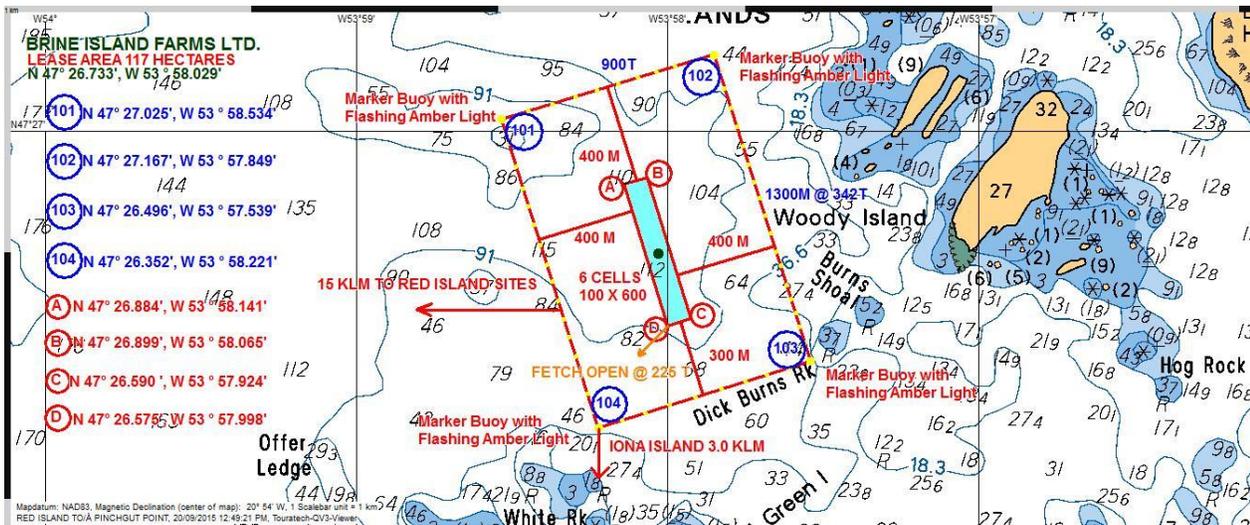
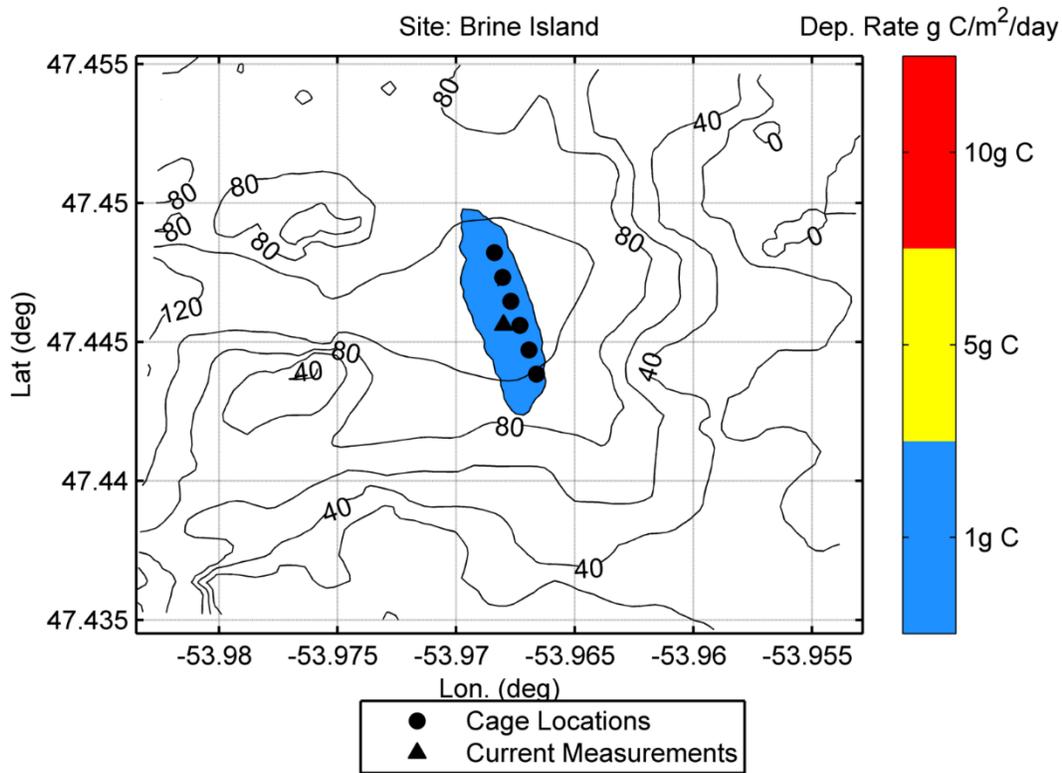


Figure 3-20: Brine Island depositional contours



3.11 Iona Islands

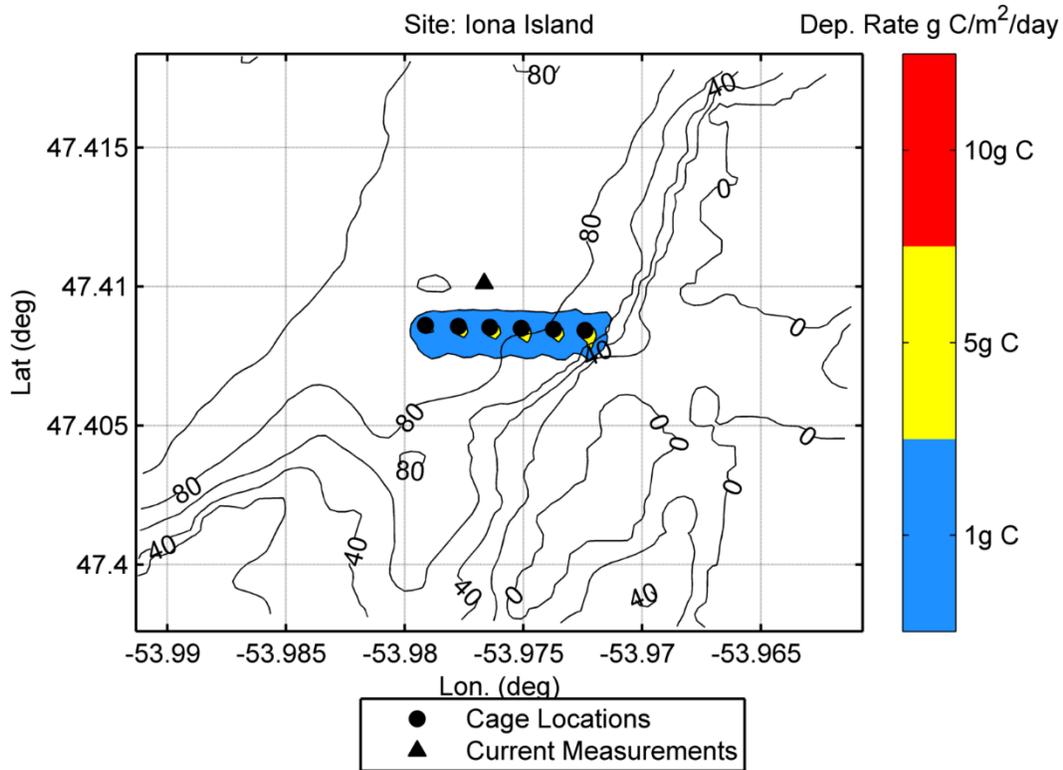
Table 3-11: Iona Island depth layers

Farm Site	Average water depth at current meter (m)	Depth layer	Number of records	Record length (minutes)	Location of depth layer
Iona Islands (47.4086N, 53.9750W)	98 m	Near-Surface	2159	20	68 m above bottom
		Mid-Depth	2159	20	33 m above bottom
		Near-Bottom	2159	20	3 m above bottom

Figure 3-21: Iona Islands map



Figure 3-22: Iona Islands depositional contours



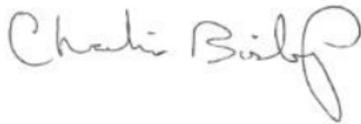
4.0 CLOSURE

Amec Foster Wheeler has prepared this Aquaculture Benthic Depositional Modeling Report for Grieg NL Seafarms Ltd. as part of their Aquaculture Activities Regulations permitting requirements. Any questions associated with this report should be directed to the undersigned and we appreciate the opportunity to conduct this work on your behalf.

Yours sincerely,

**Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited**

Prepared by:



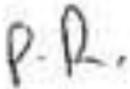
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5.0 REFERENCES

Cromey, C.J., Nickell, T.D. and Black, K.D., 2002. DEPOMOD—modelling the deposition and biological effects of waste solids from marine cage farms. *Aquaculture*, 214(1), pp.211-239.

Fisheries and Oceans Canada (DFO). 2016. Annex A DEPOMOD Canada Methods and Settings v1.6. Stucchi, D. and Chamberlain J. (eds) Canadian Science Advisory Secretariat (CSAS) Publication. 29 pp.

Grieg NL. 2016. Placentia Bay Atlantic salmon aquaculture project (Part 1 & Part 2), Registration of an Undertaking under the Environmental Assessment Regulations, 203, Section 29. Prepared by Grieg NL Nurseries Ltd. And Grieg NL Seafarms Ltd. 559 pp.

Appendix VIII
DHI Report – Grieg Seafarms, Newfoundland,
Hydrographic Surveys, March 2016

Grieg Seafarms, Newfoundland

Hydrographic surveys



Grieg Seafood BC Ltd

Report

March 2016

This report has been prepared under the DHI Business Management System certified by Bureau Veritas to comply with ISO 9001 (Quality Management)

ISO 9001
Management System Certification

BUREAU VERITAS
Certification Denmark A/S



Grieg Seafarms, Newfoundland

Placentia Bay, current measurements

Prepared for Grieg Seafood BC Ltd
Represented by Knut Skeidsvoll



View of Placentia Bay

Project manager	Lindsey Aies
Quality supervisor	Ulrik Lumborg
Project number	11819009
Approval date	11 March 2016
Revision	1.0
Classification	Confidential



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1 Introduction

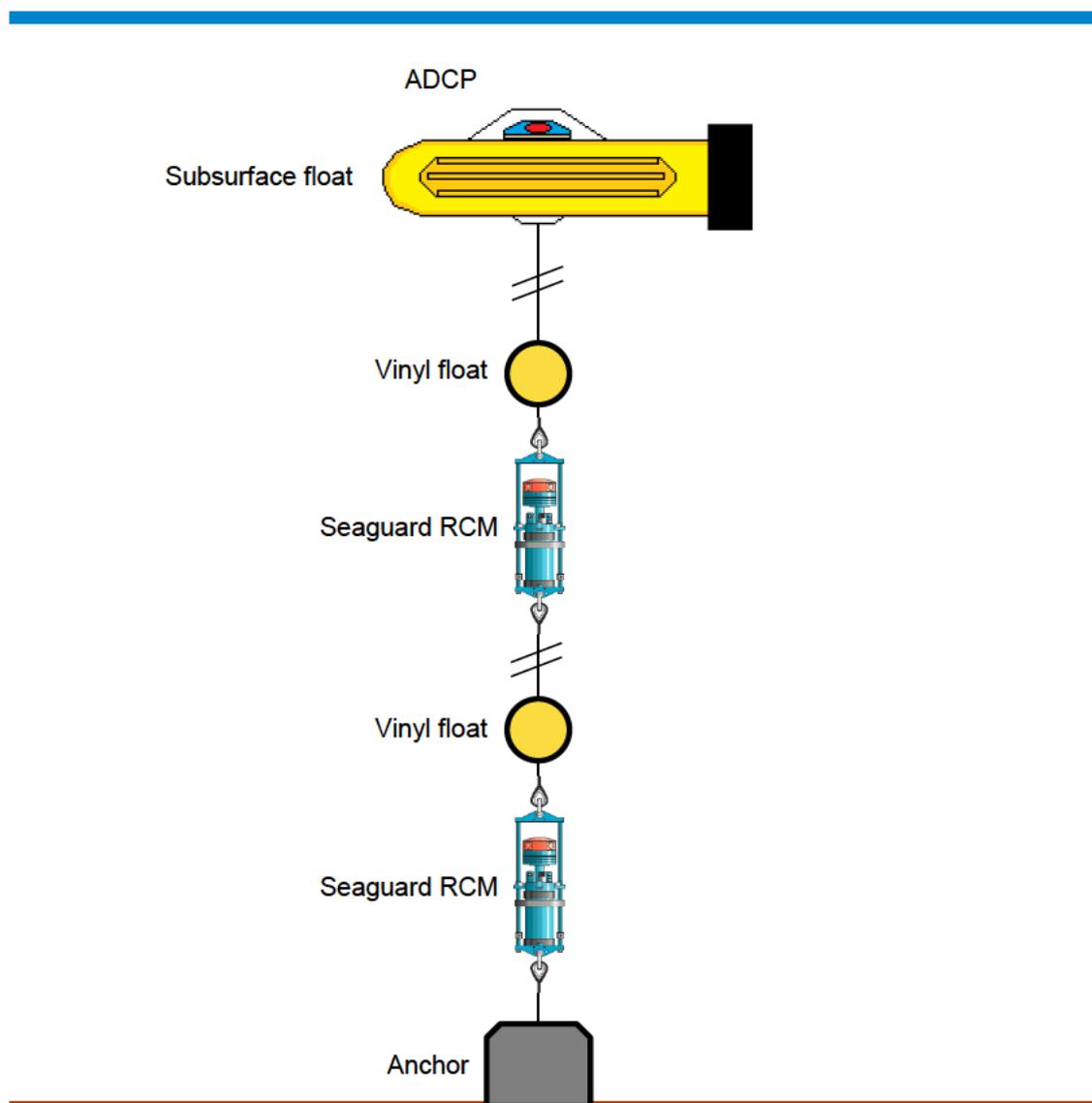
Grieg Seafarms has contracted with DHI to undertake hydrographic surveys in connection with application for establishment of new sites in Placentia Bay, Canada.

This report covers task undertaken from January to March 2016 and includes current measurements at 11 locations. Current measurements are taken at 3 points in the water column.

At all locations the aim was to document current speed and –direction during a period of 1 tidal period. Due to the rough weather during the survey period the total length of each deployment varies. The majority of deployment was over 24 hours where in three instances the deployment was only slightly less than 24 hours.

The system was compromised of two Aanderaa Seaguard RCMs and a RDI 600 kHz Workhorse Sentinel ADCP in conjunction with a subsurface float.

The system deployment is illustrated in the figure below.



Schematic view of the deployed system. The deployment was similar for all survey sites

2 Current Data

2.1 Rushoon BMA

2.1.1 Gallows Harbour

The system was placed at the follow coordinates:

Latitude: 47° 21.311' N

Longitude: 54° 41.673' W

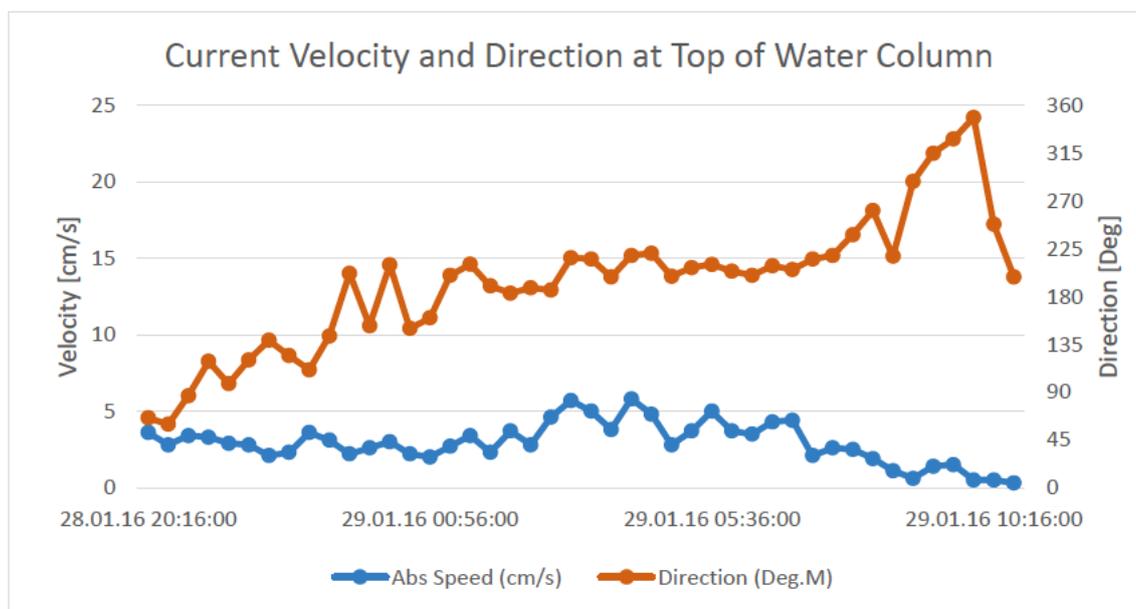
The system was deployed on the 28th of January 2016 at 20:00 UTC and recovered on the 29th of January 2016 at 11:00 UTC.

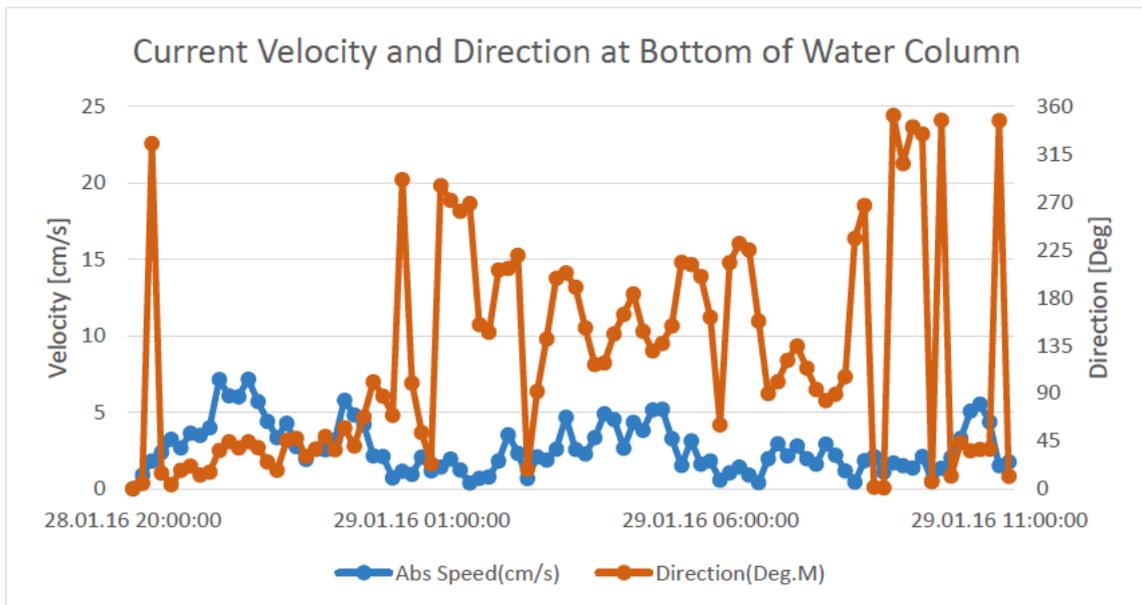
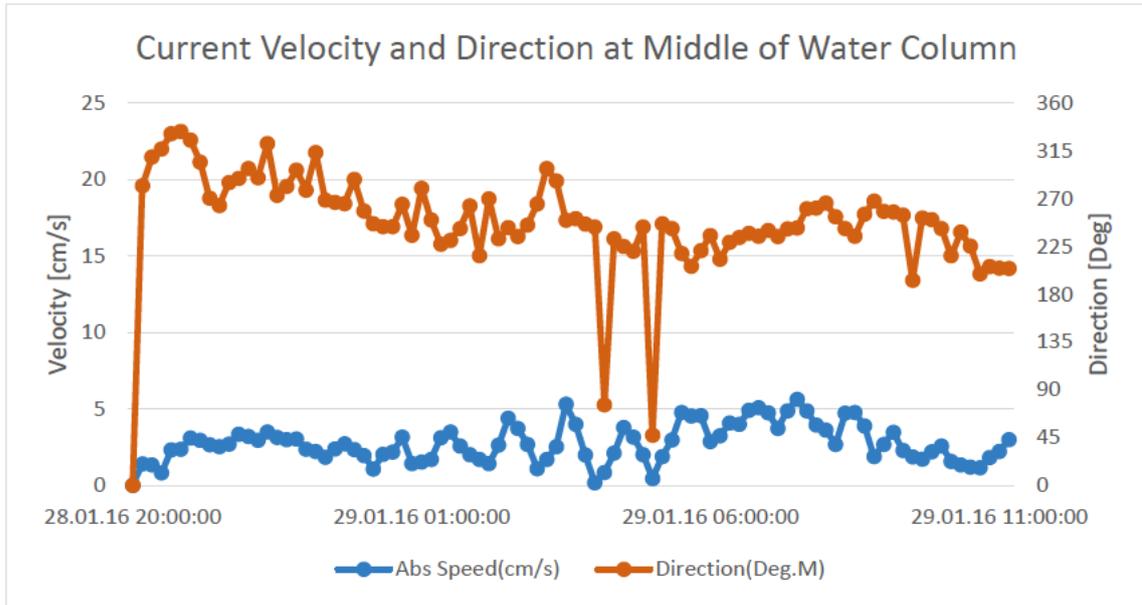
Displayed current measurements were taken at the following depths:

Top: 30 m

Middle: 70 m

Bottom: 110 m





2.1.2 Long Island

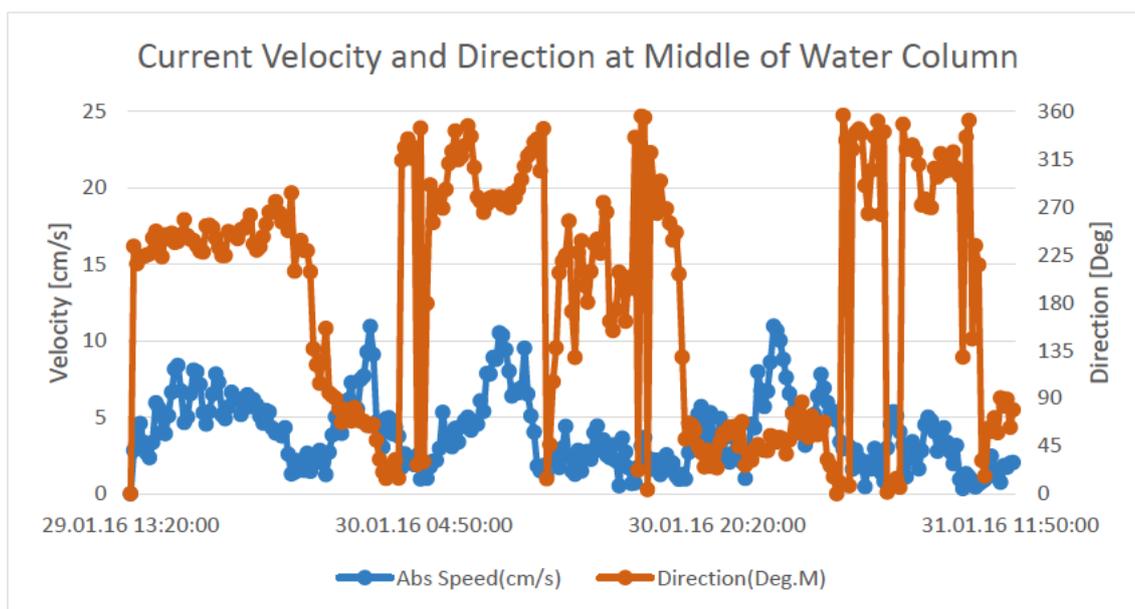
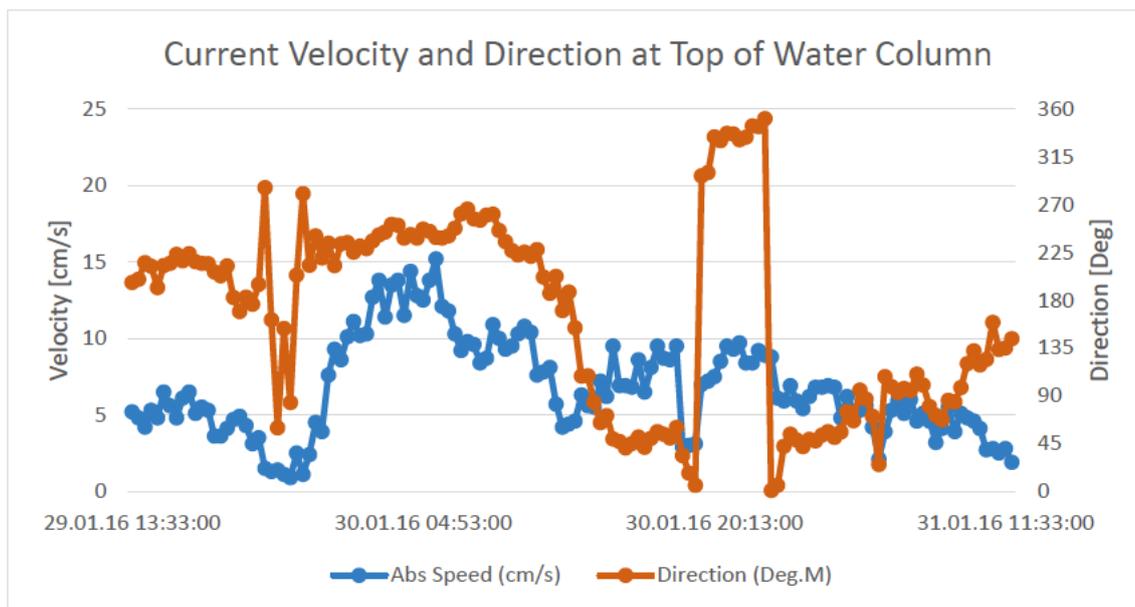
The system was placed at the following coordinates:

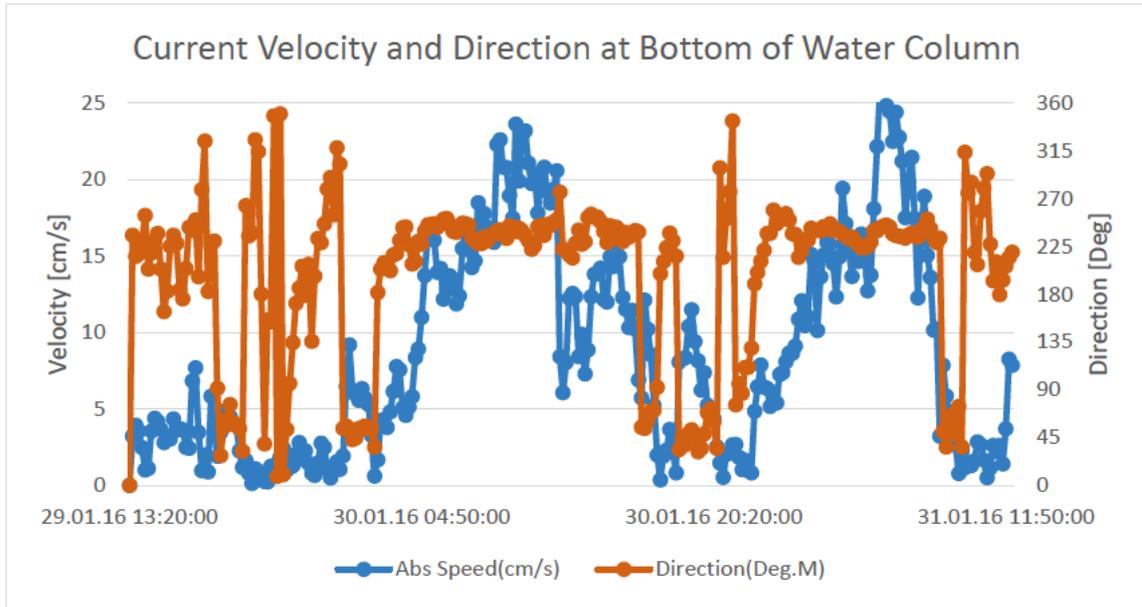
Latitude: 47° 19.881' N
 Longitude: 54° 41.858' W

The system was deployed on the 29th of January 2016 at 13:20 UTC and recovered on the 31st of January 2016 at 12:00 UTC.

Displayed current measurements were taken at the following depths:

Top: 30 m
 Middle: 87 m
 Bottom: 135 m





2.1.3 Oderin Island

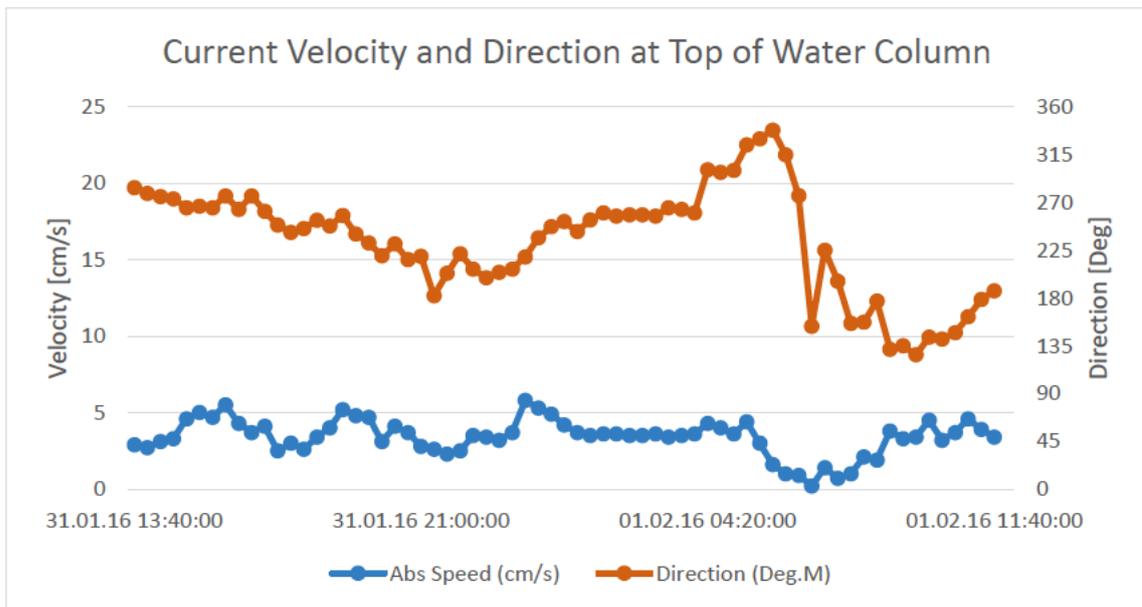
The system was placed at the follow coordinates:

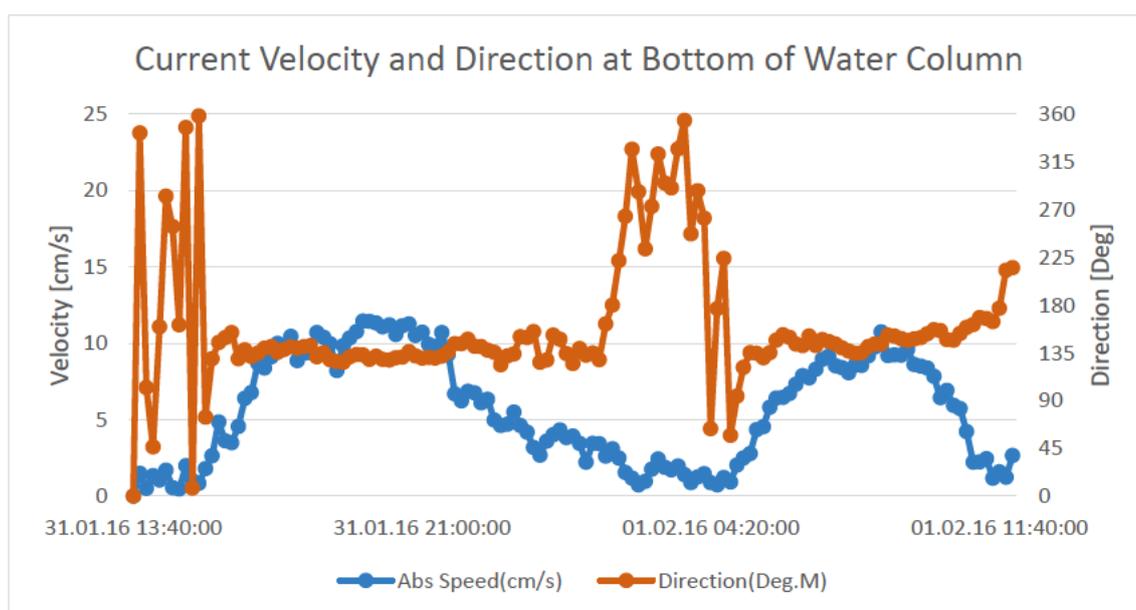
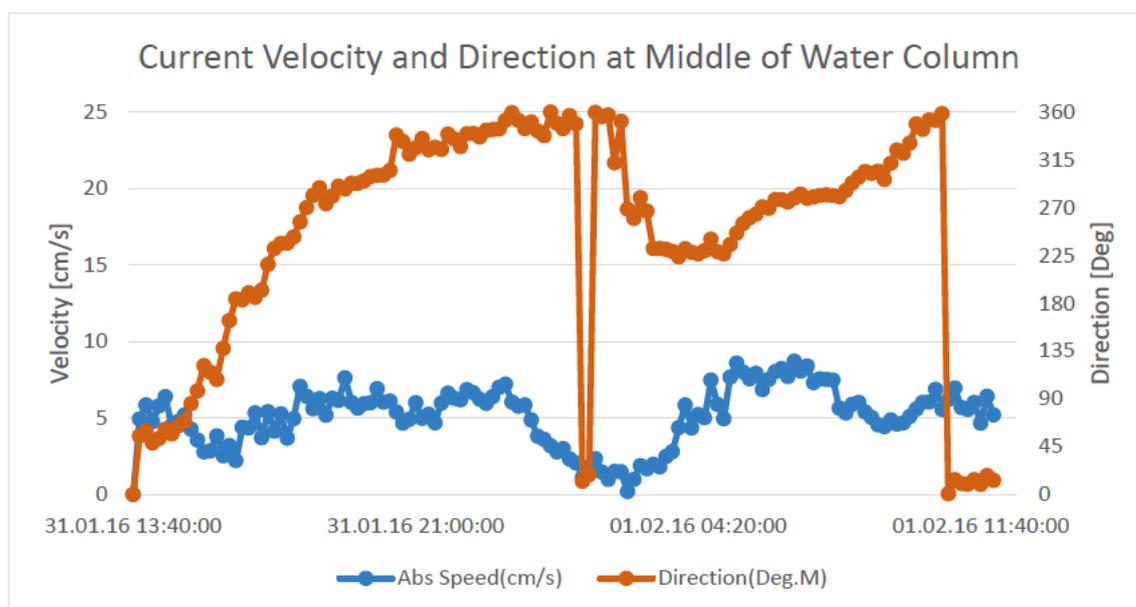
Latitude: 47° 18.030' N
 Longitude: 54° 51.470' W

The system was deployed on the 31st of January 2016 at 13:30 UTC and recovered on the 1st of February 2016 at 11:45 UTC.

Displayed current measurements were taken at the following depths:

- Top: 30 m
- Middle: 58 m
- Bottom: 80 m





2.2 Merasheen BMA

2.2.1 Valen Island

The system was placed at the follow coordinates:

Latitude: 47° 31.500' N
 Longitude: 54° 23.533' W

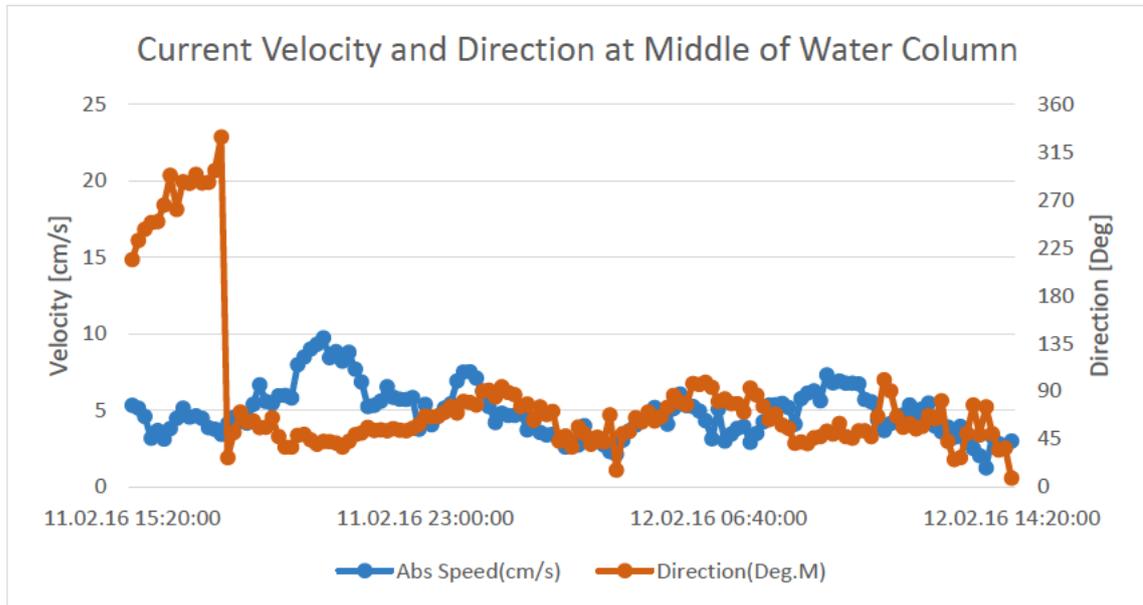
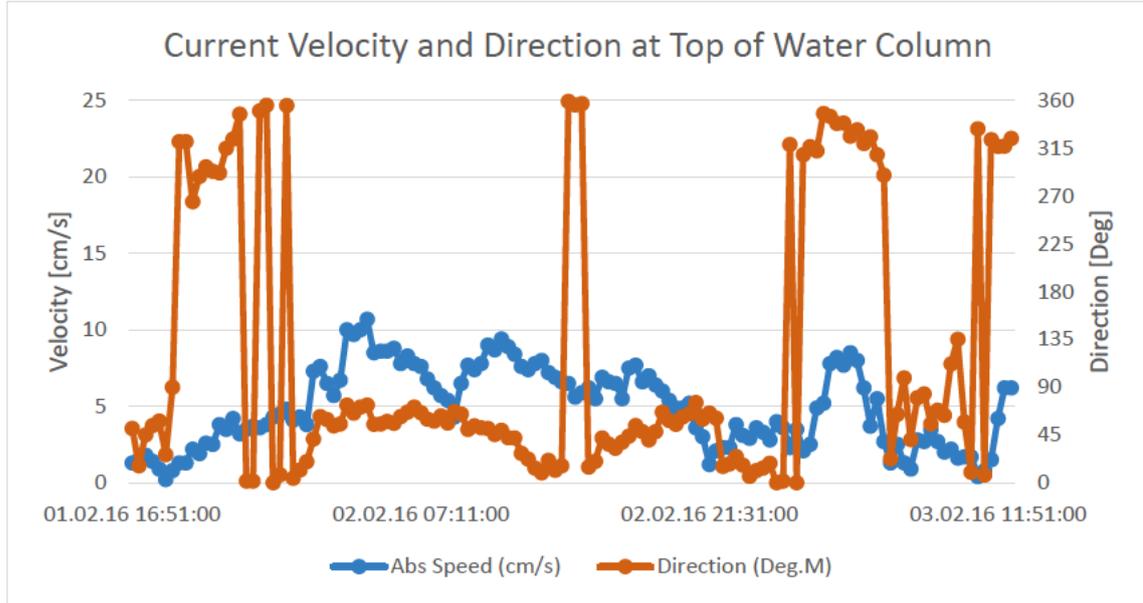
The system was deployed on the 1st of February 2016 at 16:30 UTC and recovered on the 3rd of February 2016 at 13:30 UTC.

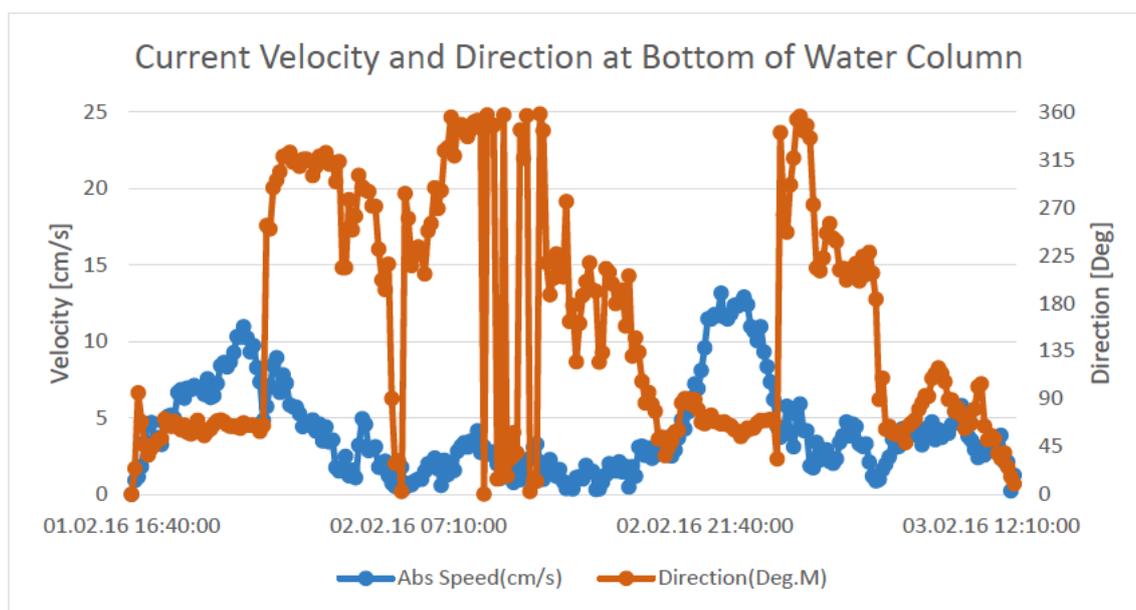
Displayed current measurements were taken at the following depths:

Top: 25 m

Middle: 130 m

Bottom: 235 m





2.2.2 Chambers Island

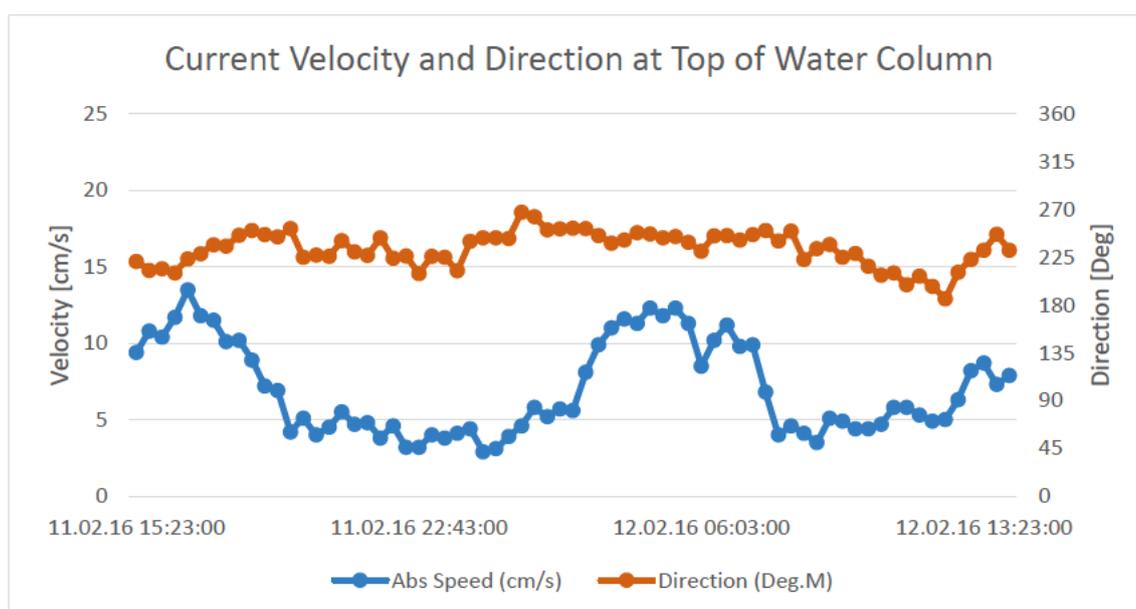
The system was placed at the follow coordinates:

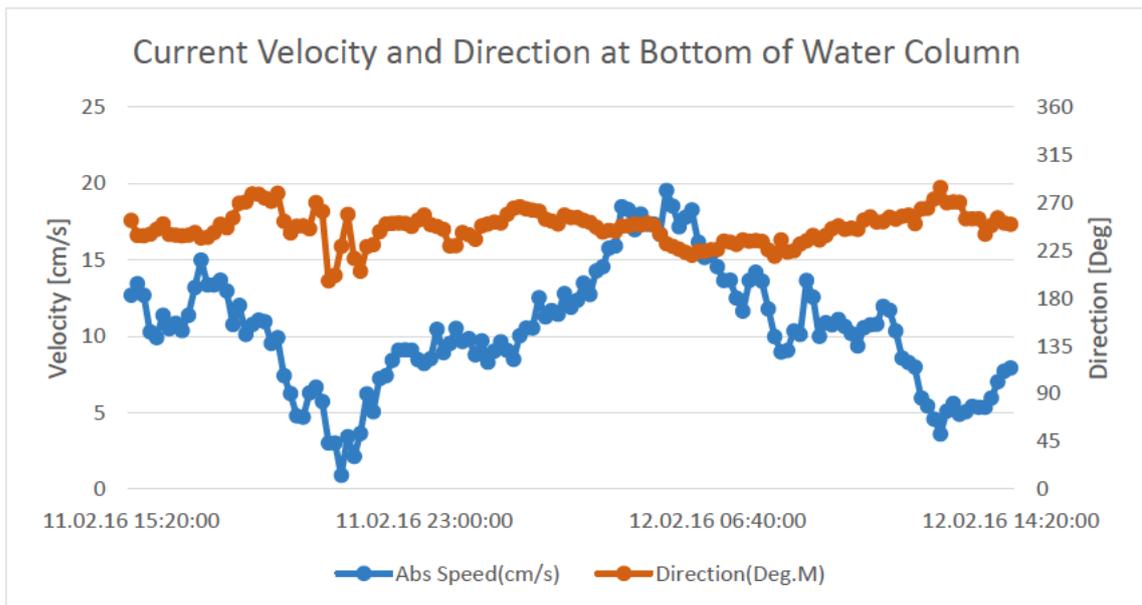
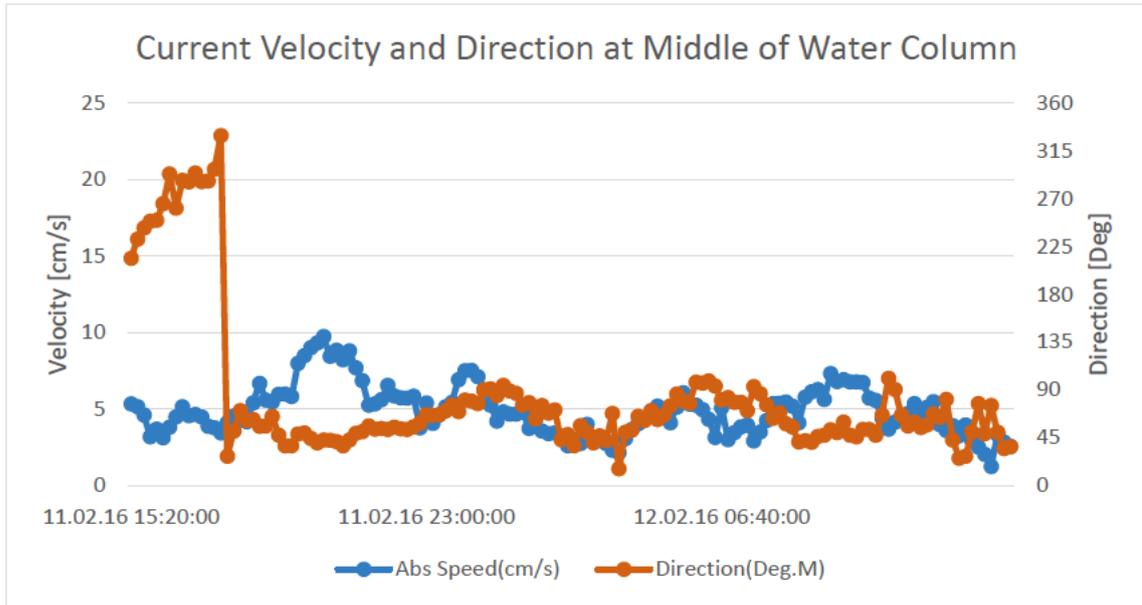
Latitude: 47° 34.728' N
 Longitude: 54° 20.926' W

The system was deployed on the 11th of February 2016 at 15:00 UTC and recovered on the 12th of February 2016 at 14:30 UTC.

Displayed current measurements were taken at the following depths:

Top: 30 m
 Middle: 160 m
 Bottom: 265 m





2.2.3 Ship Island

The system was placed at the following coordinates:

Latitude: 47° 38.740' N

Longitude: 54° 16.662' W

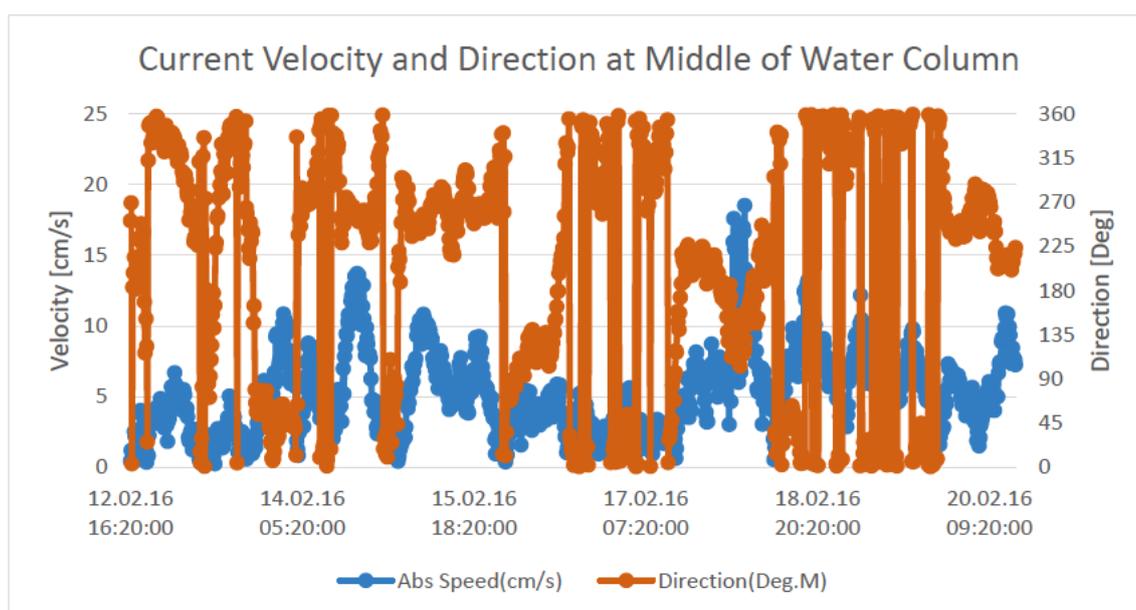
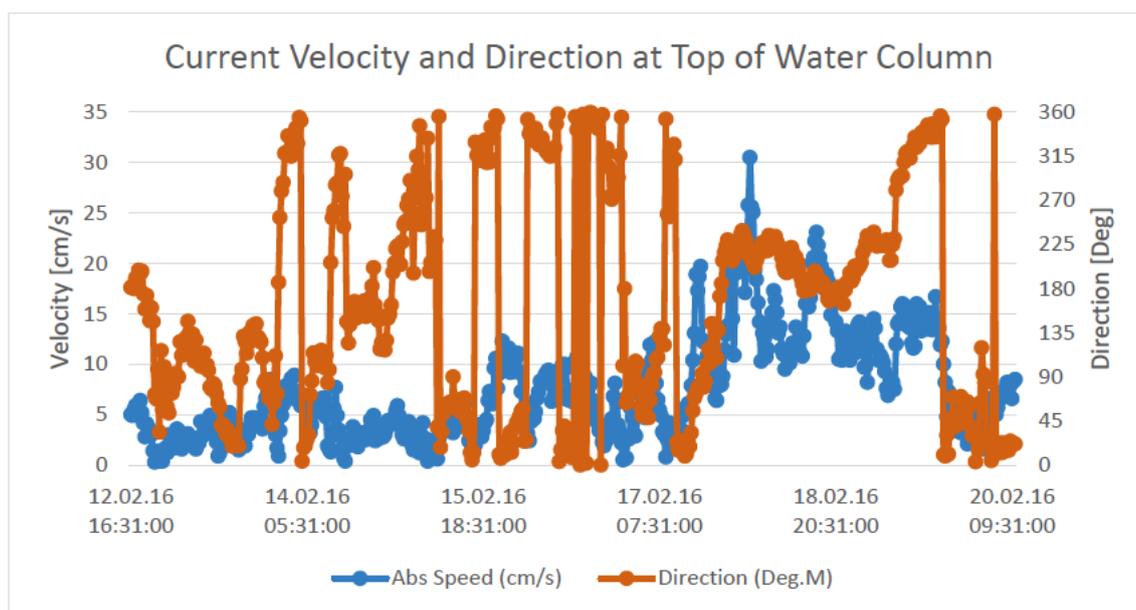
The system was deployed on the 12th of February 2016 at 16:15 UTC and recovered on the 20th of February 2016 at 15:00 UTC.

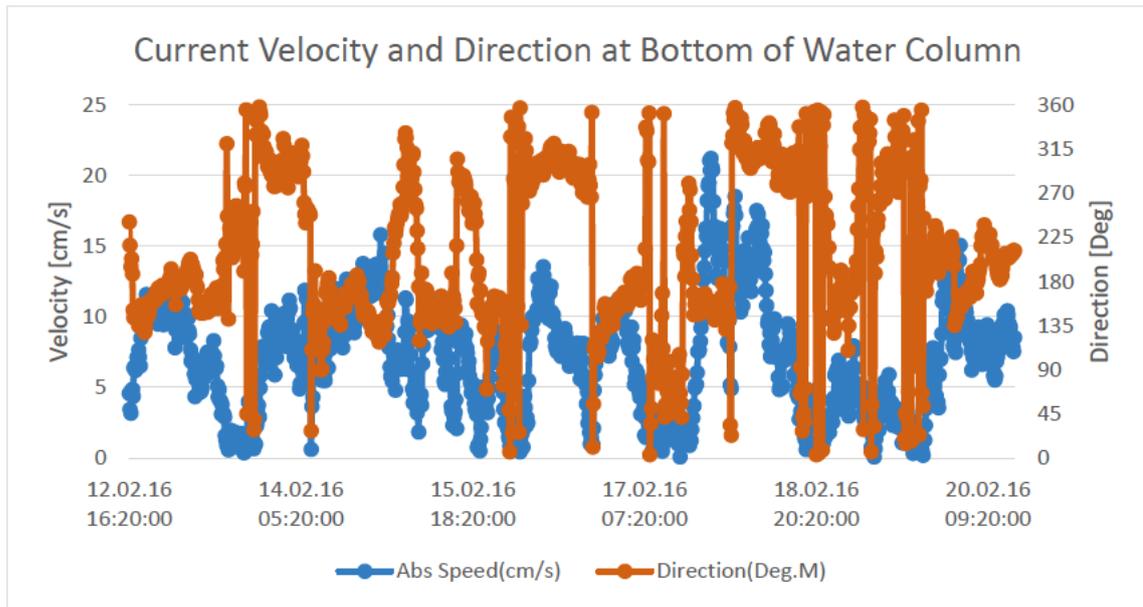
Displayed current measurements were taken at the following depths:

Top: 30 m

Middle: 115 m

Bottom: 200 m





2.3 Red Island BMA

2.3.1 Butler Island

The system was placed at the follow coordinates:

Latitude: 47° 34.183' N

Longitude: 54° 06.930' W

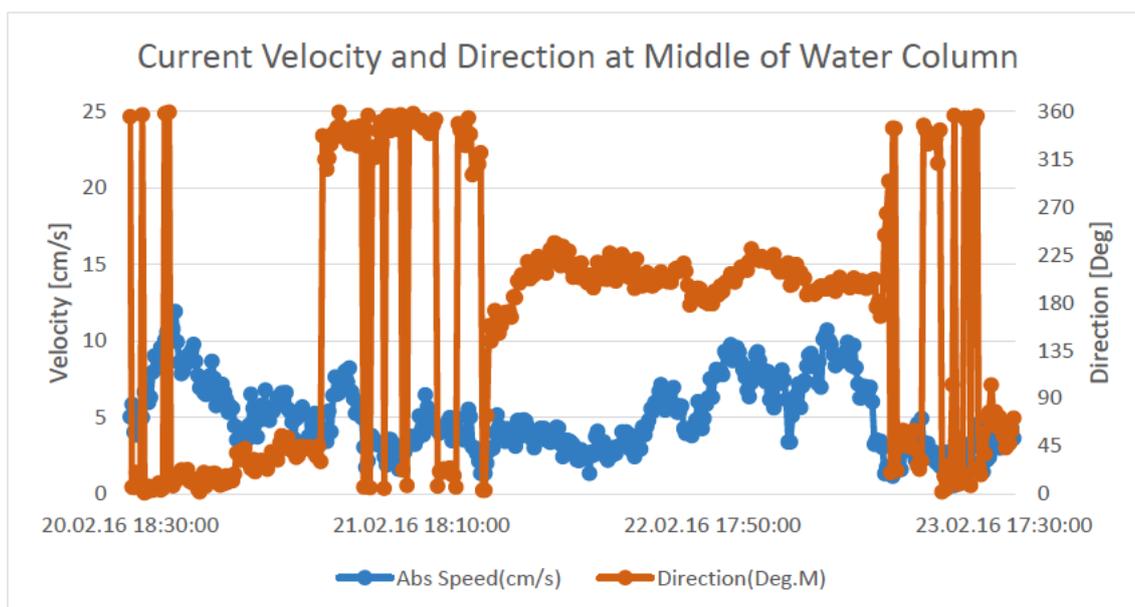
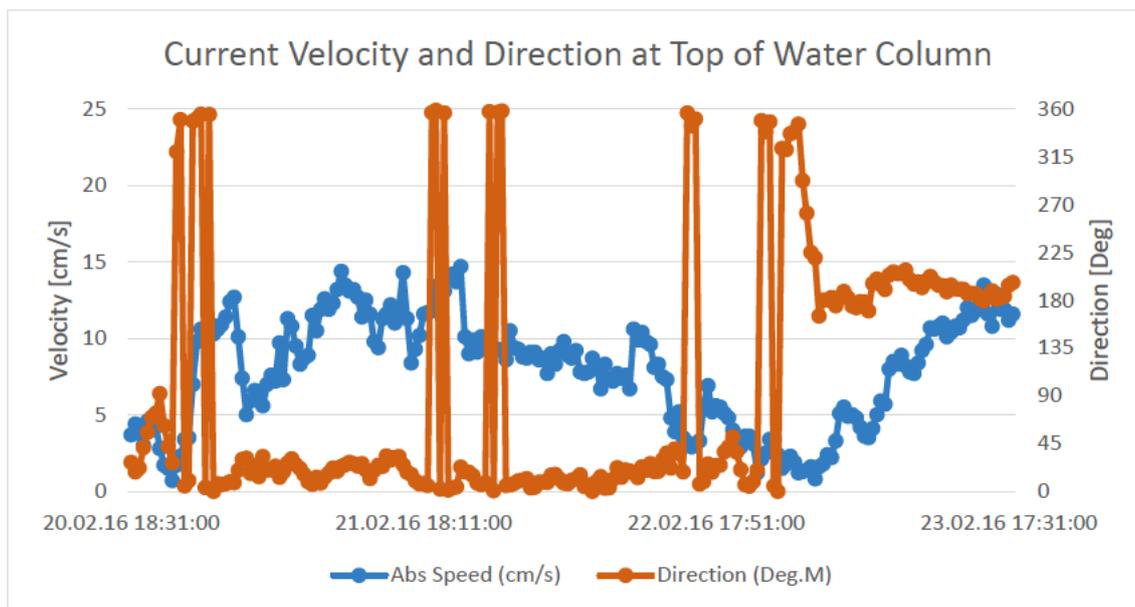
The system was deployed on the 20th of February 2016 at 18:00 UTC and recovered on the 23rd of February 2016 at 19:00 UTC.

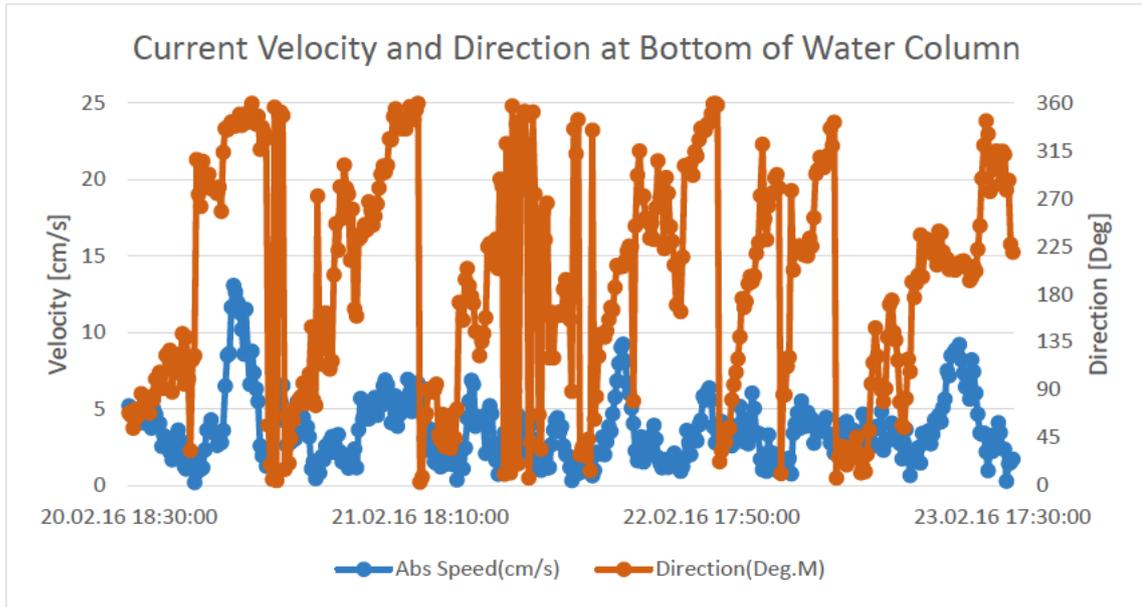
Displayed current measurements were taken at the following depths:

Top: 30 m

Middle: 70 m

Bottom: 100 m





2.3.2 Red Island

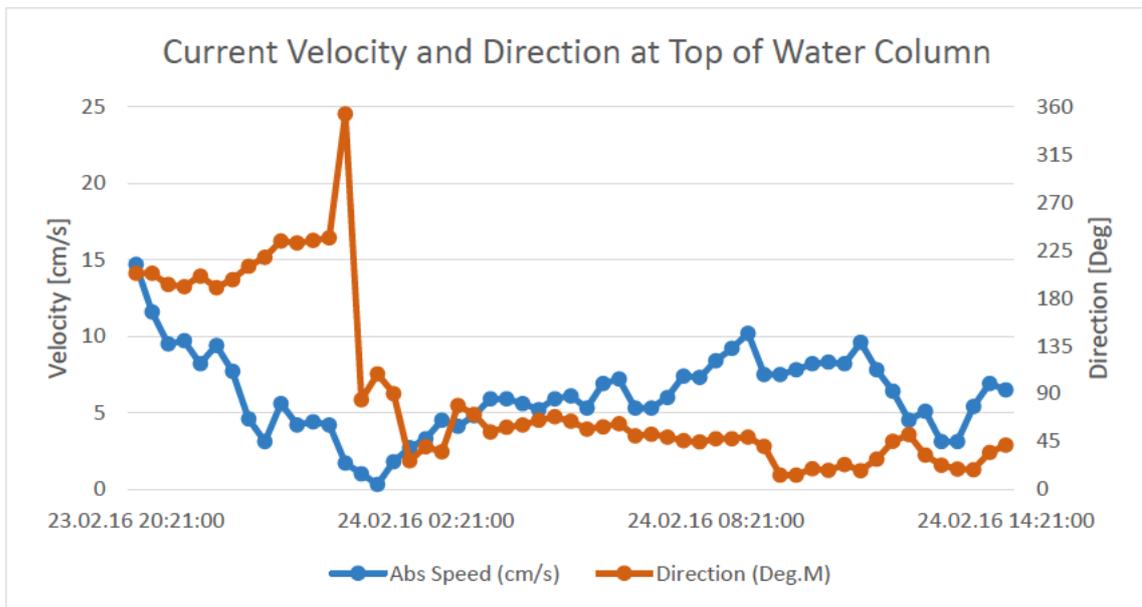
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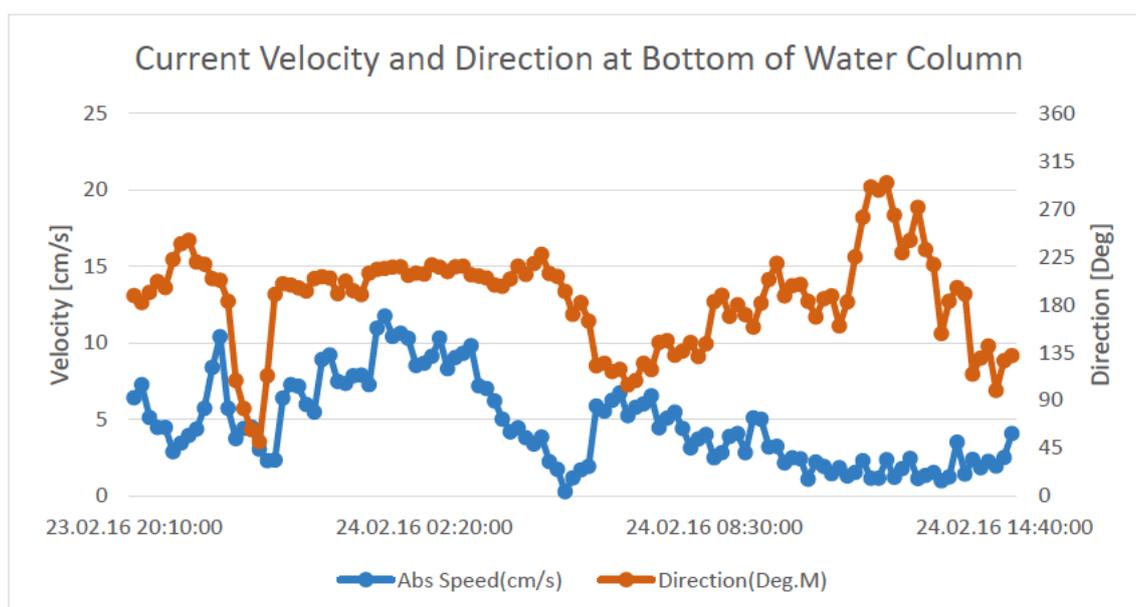
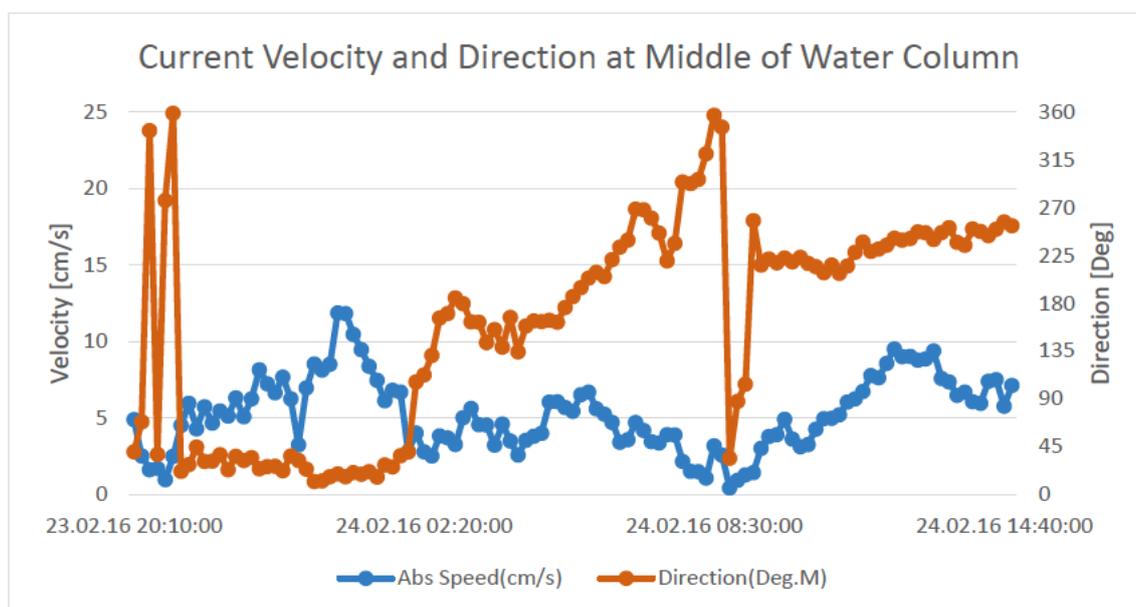
Latitude: 47° 32.237' N
 Longitude: 54° 09.019' W

The system was deployed on the 23rd of February 2016 at 20:00 UTC and recovered on the 24th of February 2016 at 15:00 UTC.

Displayed current measurements were taken at the following depths:

Top: 30 m
 Middle: 75 m
 Bottom: 105 m





2.3.3 Darby Harbour

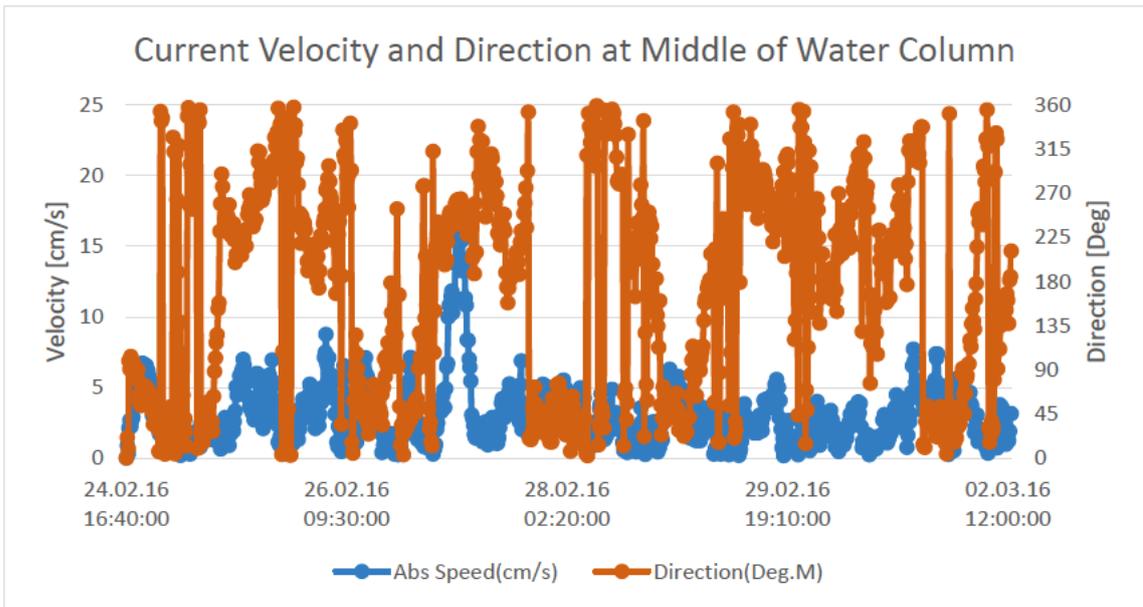
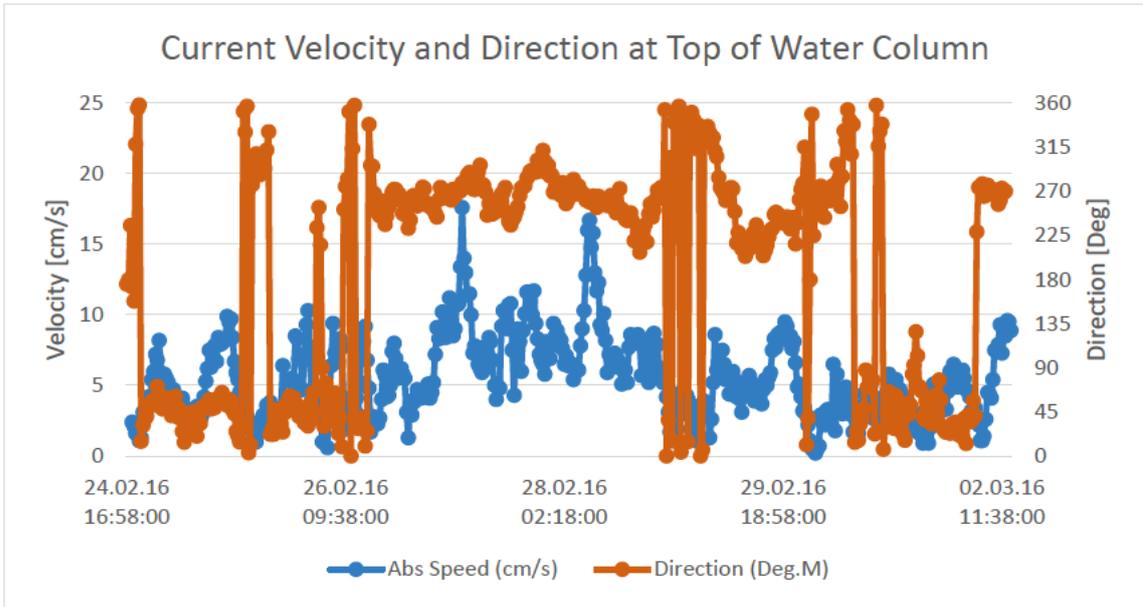
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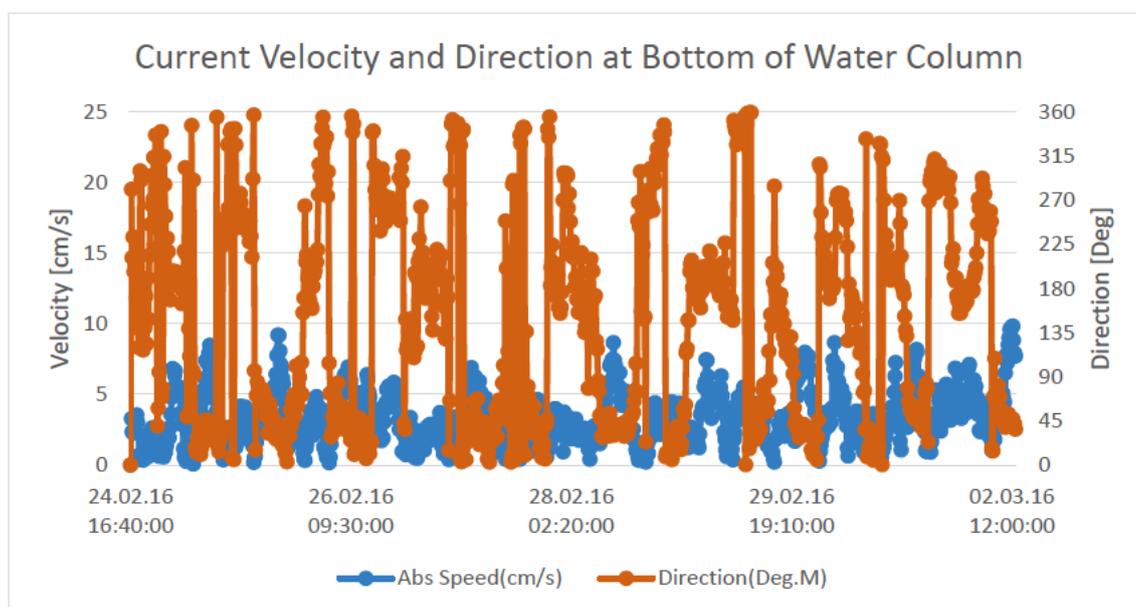
Latitude: 47° 28.720' N
 Longitude: 54° 11.227' W

The system was deployed on the 24th of February 2016 at 15:30 UTC and recovered on the 2nd of March 2016 at 12:30 UTC.

Displayed current measurements were taken at the following depths:

- Top: 30 m
- Middle: 80 m
- Bottom: 122 m





2.4 Long Harbour BMA

2.4.1 Brine Islands

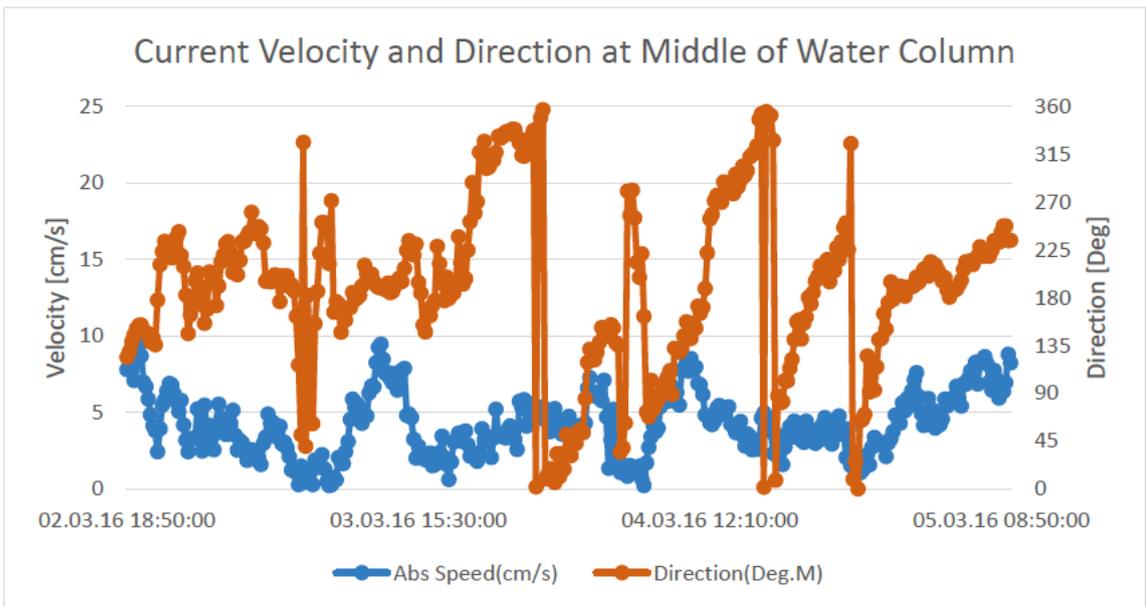
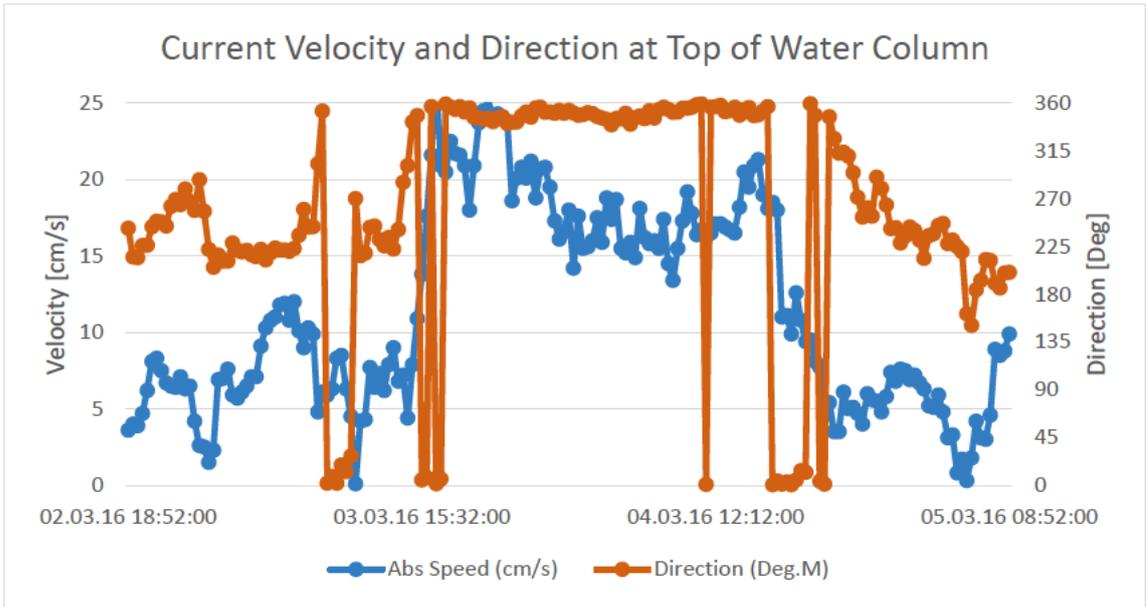
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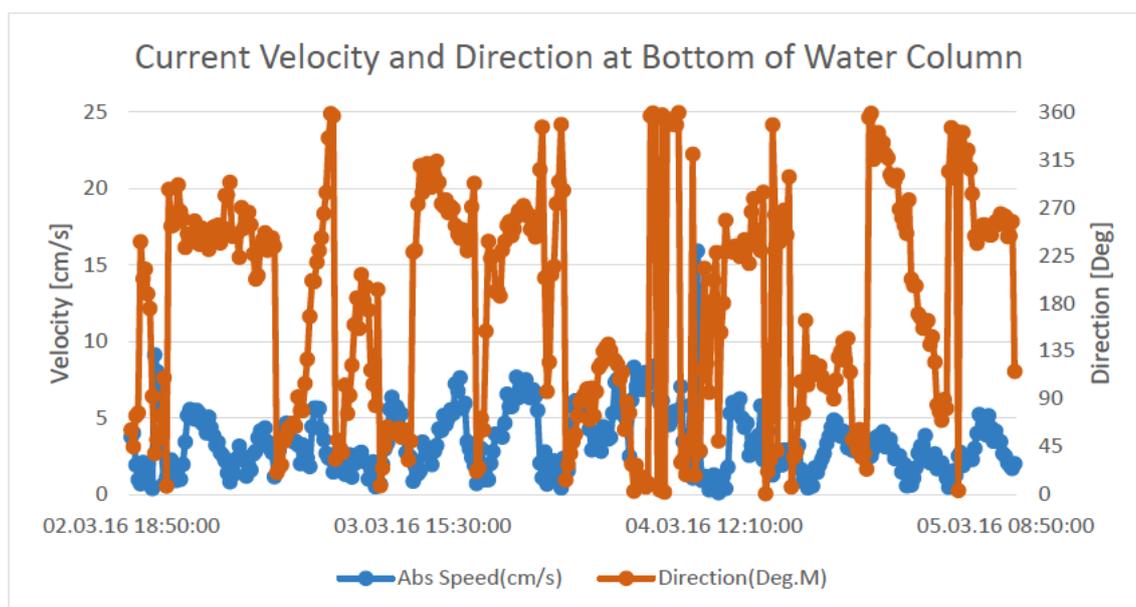
Latitude: 47° 26.736' N
Longitude: 53° 58.079 W

The system was deployed on the 2nd of March 2016 at 15:00 UTC and recovered on the 5th of March 2016 at 09:45 UTC.

Displayed current measurements were taken at the following depths:

Top: 30 m
Middle: 76 m
Bottom: 115 m





2.4.2 Iona Islands

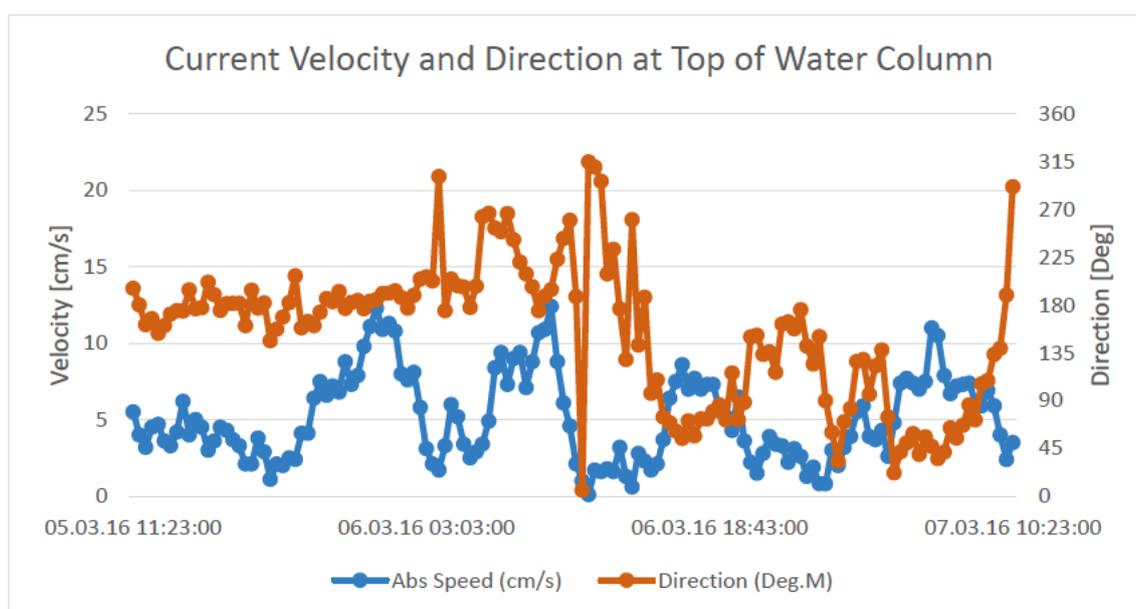
The system was placed at the following coordinates:

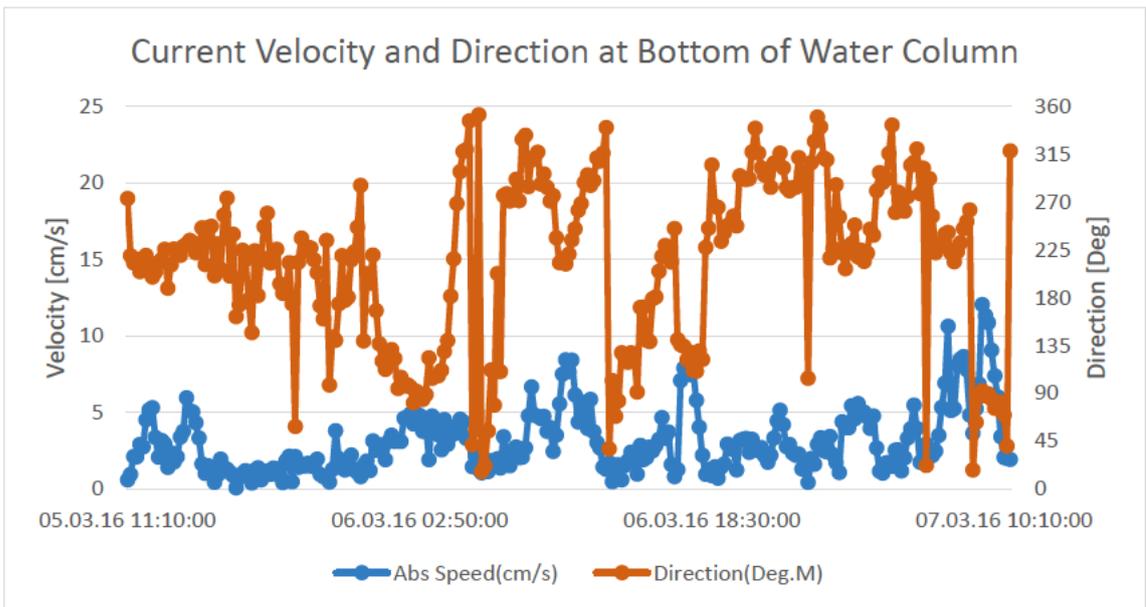
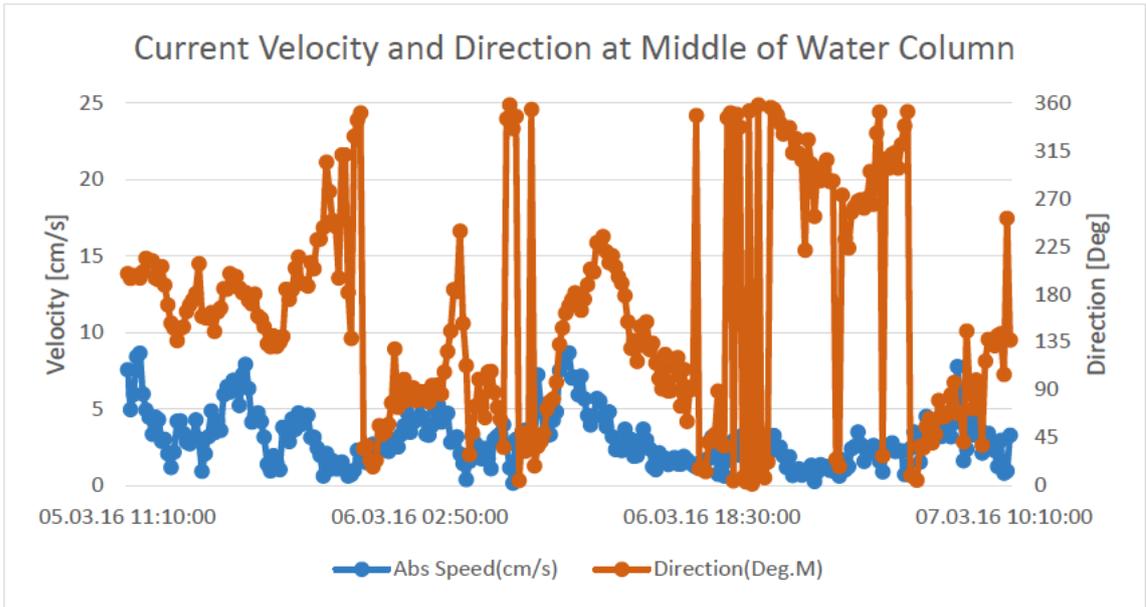
Latitude: 47° 24.607' N
 Longitude: 53° 58.600 W

The system was deployed on the 5th of March 2016 at 11:00 UTC and recovered on the 7th of March 2016 at 10:45 UTC.

Displayed current measurements were taken at the following depths:

Top: 30 m
 Middle: 65 m
 Bottom: 95 m





3 Conclusion

Current parameters were measured in Placentia Bay in the period January to March 2016. The current measurement platform was installed on 11 sites during the period. The total monitoring period varied from site to site between 20 hours up to 7 days.

The general impression is that the current speed is low at all sites. Only on Ship Island, Long Island and Brine Islands were speeds in excess of 20 cm/sec measured which is still considered low. It is, however, noted that the monitoring periods were very short.