TECHNICAL MEMO

UiS-Relevant regelverk havbruk til havs
Relevant regulations for Offshore aquaculture in Norway

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Applicable contract(s) governing the provision of this Report:

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1 EXECUTIVE SUMMARY

This technical memo includes an overview of technical codes and standards that may be relevant for “Havbruk til havs” (HTH) in Norway, as well as response from the industry and relevant governmental agencies on important aspects related to regulations for HTH. The latter is achieved through interviews and a survey with a number of relevant actors.

Short descriptions of the relevant codes and standards are given, but attempts have been made to keep the information as objective as possible. Hence, further evaluations of the suitability of the code or standard are not made. It should also be noted that the suitability will depend on the specific installation and systems onboard.

The response from the aquaculture industry and governmental agencies is presented in sections 6 and 7. Section 6 shows sorted information from individual interviews made in the autumn 2022 with invited representatives from designers, operators and authorities. The information from these interviews is anonymised. Section 7 presents the results from a survey that was performed in connection with a workshop with totally 18 representatives from the same branches 17.02.2023.

The main responses from the interviews and survey are:

- Today’s aquaculture rules are assessed not to be relevant for HTH.
- The industry players would like the authorities to define a safety level that the industry can relate to and that this safety level is comparable with the safety level in the oil and gas industry in Norway, however taking into consideration the relevant risks for aquaculture.
- The regulations for aquaculture should in general be functional based to cater for new innovations and it is seen as very important that the functional-based regulations are followed-up by guidelines that describe design principles and standards/codes that define the authorities' expectations for fulfilling the functional requirements.
- The responsibility to ensure that the target safety level in the regulations is met should be owned by the operators and not delegated to accreditation companies as for traditional aquaculture. This is in line with requirements to operators in the O&G industry.
- The industry sees limited coordination between different authorities today. For HTH it is expected from the industry that one authority will be given the role as a coordinating authority.
- Requirements and expectations from the authorities to risk management in HTH need to be more clearly defined compared to traditional aquaculture.
- Risk management should be based on barrier management where a holistic risk management system is the basis.

2 INTRODUCTION

As part of the project “Lavutslipps verdikjede for havbruk til havs" https://gronnplattform.stiimaquacluster.no/om-prosjektet/ DNV is supporting the University in Stavanger (UiS) with an overview of technical regulations and relevant standards which can be applicable for design of aquaculture facilities to be operated offshore. The objective is to identify existing regulations, technical codes and standards commonly used for assets in Norwegian waters, and onshore, that can be applicable for "Havbruk til Havs” (HTH). The list is not exhaustive but covers relevant regulations within each safety system preventing risk in design and operation.

The aim is to ensure safe design and safe operations for personnel, asset, and the environment including preventing fish escape in which safe design can be defined as a design with freedom of risk which is not tolerable, /3/. Hence, the

design need to account for the introduction of new and changed risks as a result of operation offshore. This study focus on codes and standards relevant to handle the risks related to unwanted events including:

- Loss of stability
- Fire and explosion
- Falling objects from lifting activity
- Loss of structural integrity
- Ship collision
- Loss of position

In ensuring safe design and operations the barriers and measures needed to prevent unwanted events to occur and to mitigate and reduce the potential consequences barriers must be identified and included in the design, and maintained during operation. The safety level is defined through specifying the barriers performance requirements. Performance requirements are often given in codes, standards or regulations, and in some cases defined as company specific requirements.

Typical safety systems which will be part of design, and which are barriers with regards to the unwanted events specified above are:

- Structural integrity
- Communication and navigation systems
- Fire protection
- Emergency power and emergency lightning
- Escape and evacuation
- Rescue and safety equipment
- Ballast system
- Green sea barriers
- Dropped object protection

These safety systems will contribute to manage the risk for personnel, asset, and the environment including preventing fish escape. The assessment of how applicable today's regulations are and the identification of other relevant codes and standards for operating offshore are based on the safety systems listed above. The assessment is based on an assumption that offshore fish farms shall have a safety level similar to other offshore and marine industries with regards to personnel, asset, and the environment.

3 ABREVIATIONS

The abbreviations listed in Table 3-1 are used in this memo.

Table 3-1 Abbreviations

Abbreviation	Description
AoC	Acknowledgement of compliance (from PSA)
API	American Petroleum Institute
CE	Conformité Européenne - CE marking indicates that a product has been assessed by the manufacturer and deemed to meet EU safety, health and environmental protection requirements.
CEN	European Standardisation Committee
COLREG	Convention on the International Regulations for preventing collisions at sea
DNV-OS-	DNV offshore standard
DNV-RU-	DNV rules for classification
DNV-ST-	DNV standard
DP	Dynamic Positioning
EEMUA	Engineering Equipment and Material User Association

Abbreviation	Description
EHSR	Essential health and safety requirements
EN	European Standards (abbreviated EN, from the German name Europäische Norm ("European Norm")
FPSO	Floating production storage and offloading
GMDSS	Global maritime distress and safety system handbook 2018
HDPE	High-density polyethylene
HSE	Health, safety and environment
HTH	Havbruk til havs (offshore aquaculture)
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IEC	International Electrotechnical Commission
IMCA	The International Marine Contractors Association
IMO	International Maritime Organisation. Responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.
ISO	International Organization for Standardization
LRFD	Load and Resistance Factor Design
MD	European Machinery Directive 2006/42/EC
MODU	Mobile offshore drilling unit
MOU	Mobile offshore unit
MTB	Maximum permitted biomass (maksimalt tillatt biomasse)
NCA	Norwegian Coastal Administration (Kystverket)
NMA	Norwegian Maritime Authority (Sjøfartsdirektoratet)
NORSOK	Standards developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations.
NS	Norsk Standard (Standards established and published by Standard Norway)
OS	Offshore Standard
PSA	Petroleum Safety Authority Norway
PUD	“Plan for utbygging og drift” - Planning document for a petroleum field on the Norwegian continental shelf
SOLAS	The International Convention for the Safety of Life at Sea - international treaty concerning the safety of merchant ships. It ensures that ships registered by signatory States comply with minimum safety standards in construction, equipment and operation of ships.

4 REGULATORY BASIS

4.1 General

In developing a safe design, the design will be based on code and standards which form the basis for ensuring the relevant regulations and acts are fulfilled, see Figure 4-1. The challenge for aquaculture going offshore is to identify and define the regulatory requirements, the code and standards which will give the required safety level handling the new risks and operational environment where no or little experience exists in the aquaculture industry per today.

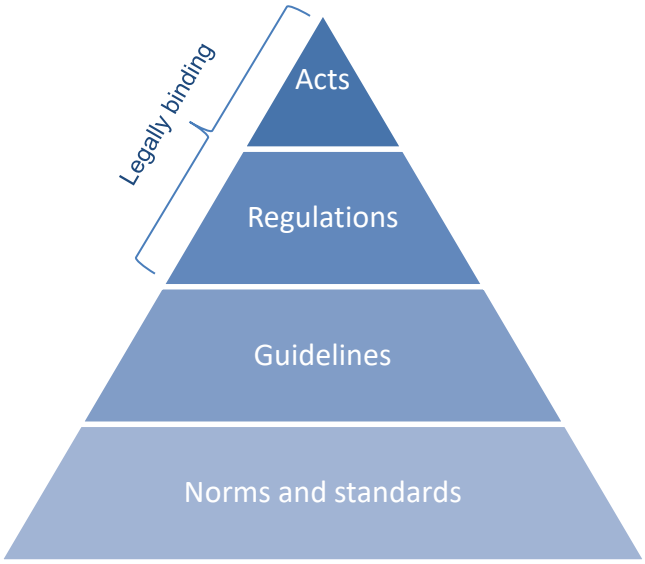

Figure 4-1 Hierarchy of regulatory requirements

The acts governing health, safety, and the environment for designing and operating an aquaculture facility in shelter areas are:

- Akvakulturloven
- Forurensingsloven
- Havne- og farvannsloven
- Arbeidsmiljøloven
- Brann og eksplosjonsloven
- El-tilsynsloven

Some of key regulations with regards to safe design and operation are:

- Forskrift om krav til teknisk standard for flytende akvakulturanlegg (NYTEK-forskriften)
- Forskrift om systematisk helse-, miljø- og sikkerhetsarbeid i virksomheter (Internkontrollforskriften)
- Forskrift om internkontroll for å oppfylle akvakulturlovgivningen (IK-Akvakultur)
- Forskrift om håndtering av brannfarlig, reaksjonsfarlig og trykksatt stoff
- Arbeidsplassforskriften
- Akvakulturdriftsforskriften

Most of the acts jurisdiction currently includes the Norwegian continental shelf where offshore aquaculture facilities are to be located. Some of the acts and regulations are however not designed to account for aquaculture operation offshore. Hence, the code and standards defined do not account for the change in operational environment, new risks, and new technology.

The oil and gas and the maritime sectors in Norway have developed code and standards to ensure safe design and operation to accommodate the safety level defined by the Petroleum Safety Authority Norway (PSA) and the Norwegian Maritime Authority (NMA). These facilities need to safely handle the same environmental conditions and many of the same risks as an aquaculture facility offshore will experience. It is to be expected that many of the industry standards and codes used in the maritime and offshore sectors can be used to fill the gaps of missing code and standards specific

for the aquaculture facilities to be operated offshore. However, differences in the requirements exist for the oil and gas and maritime sector and an assessment of which requirements are best suited for the aquaculture facilities offshore is needed, but is not a part of this technical memo.

When applying codes, standards and regulations from different legislations, consistent use of regulations is of major importance. Regulations are tuned such that use of the specified requirements result in a required overall level of safety for the given type of construction. Mixing codes, standards and regulations from different legislations may result in a different safety level than those from the originating legislations. Mixing of different regulations should therefore be done with care and likely supported by a gap assessmmet to better quantify the differences between the standards adopted.

4.2 Regulations valid for the safety systems

4.2.1 NYTEK regulation

The NYTEK regulation, /5/, set requirements to the structural integrity and stability of the fish farm and the systems relevant to prevent fish escape, both with regards to safe design and ensuring acceptable technical condition in operation. Hence, the requirements are set in the context of managing the environmental risk related to fish escape. The NYTEK regulation refer to NS9415:2009, /6/, in the regulation's sections. Hence, the standard's requirements are to be implemented to fulfil the regulatory requirements.

The requirements given in the regulation are not explicitly self-contained with respect to the safety level of the structural strength that shall apply for fish farming units operating offshore. To reach the required safety level of comparable offshore units, relevant design principles and standards applied for the design of these are needed.

The new version of the NYTEK regulation NYTEK23, /8/, which is to entry into force 01.01.2023 refer to the new NS9415:2021, /7/. The new version of the standard is aiming at being technology neutral, thus also being suitable for offshore fish farms. However, it has been developed with the current regulatory regime in mind. Hence, the focus is on managing risk related to fish escape. The holistic perspective of managing risk to personnel, asset and the environment is not accounted for.

This regulatory regime may need to be changed for aquaculture facilities operating offshore through developing regulations and requirements valid for managing the risk for both personnel, asset and the environment including fish escape. Hence, not one set of requirements for fish escape and another for asset or personnel. Thus, relevant and applicable rules from NS9415:2021 may be implemented in a new offshore aquaculture regulation, but not necessarily the standard in its entirety.

4.2.2 Other international codes and standards

ISO 16488 Marine finfish farms — Open net cage — Design and operation

This International Standard presents a general method to be followed for the systematic analysis, design, and evaluation of net cage marine finfish farms and is intended to provide guidelines for the design and operation of permeable net cage marine finfish farms. This standard set requirements to the owner/operator of a marine finfish farm who is responsible, through the use of a risk evaluation, for assessing the environmental conditions at a prospective site, selecting the appropriate equipment for use at the particular site, and for the safe operation of the finfish farm.

The main components should be designed according to ISO standards that are relevant for the component in question. Where ISO standards do not exist, appropriate international or regionally accepted standards should be applied to ensure an appropriate level of system safety and quality assurance. For example, the design of a steel structure should use ISO 19902 or EN 1993. Internationally accepted codes and standards that exist and which provide guidelines for the

technical design and integrity of system components may be used. However, the user must ensure that the design philosophy intended in this International Standard is met and consistent operational and human safety levels are applied.

For offshore structures ISO 16488 refers to use of ISO 19900, Petroleum and natural gas industries — General requirements for offshore structures and ISO 19901-1, Petroleum and natural as industries — Specific requirements for offshore structures — Part 1.

DNV-RU-OU-0503 Floating fish farming units and installations

Classification provides assurance in which a set of requirements laid down in rules established by DNV are met during design and construction and are maintained during operation. This implies an activity, in which a unit or installation is surveyed during construction on the basis of design approval, tested before being taken into service, and surveyed regularly during its whole operational life. The aim is to verify that the required safety standard is built in, observed, and maintained.

The RU is a classification rule set that enables floating fish farming units and installations to obtain DNV class. This RU is mainly a listing of other relevant DNV offshore standards and RUs in addition to aquaculture rules, incl. NYTEK and NS9415. Most of the referenced standards are shown in the following sections.

5 RELEVANT REGULATIONS, CODES AND STANDARDS FROM OTHER INDUSTRIES

It is assumed that offshore fish farms shall have a safety level similar to other offshore and marine industries related to safety of asset and personnel. Regulations, codes and standards within the following disciplines are thus assessed relevant covering the safety systems described in section 2.

- Structure
- Stability
- Anchoring, mooring and towing equipment
- Lifting equipment
- Communication
- Navigation
- Marine Systems
- Fire safety
- Life-saving appliances

5.1 Relevant regulations from other industries in Norwegian waters

There are no current regulations that cover all elements to ensure a safe design with regards to the risk for personnel, asset and the environment related to design and operation of offshore aquaculture in Norway. This is also the case when discussing technical regulations with requirements to safety systems. Currently, relevant standards from different regulations need to be combined to cover the total safety aspect within these areas and that the intended level of safety are ensured.

Different regulations have their strong and weak points related to the above aspects for offshore aquaculture. How to proceed to best cover all safety aspects is not within the mandate of this technical note, but it may be relevant to see

these in connection with a total regulatory framework ensuring a satisfactory level of safety in all phases and at the same time ensure that cost levels can be held within acceptable levels.

To ensure a satisfactory safety level can be done by different means. Normal denotations are prescriptive and functional based requirements. Prescriptive requirements are generally based on specific requirements to equipment or systems, while functional based requirements are based on ensuring that a function is achieved and maintained. Some examples of characteristics of performance based and functional based requirements are given below /4/:

Performance based requirements:

- Normally clearly defined requirements
- Easy to understand and follow up
- Limited flexibility for innovations
- May lead to “minimum” solutions
- Designers/yards/owner may not have a total view on risk

Functional based requirements:

- Flexible when used on new technology
- Requires high competence level at designers/yards/owner
- Uses risk analyses to achieve required safety level
- Requires some trust between parties as it allows for discretionary decisions

5.1.1 Regulatory requirements for design of facilities to be used for petroleum activities

The Facility Regulation, /9/, define requirements related to design and outfitting of facilities to be used for petroleum activities on the Norwegian Continental Shelf. It is stated that the design is to be based on the most robust and simple solutions as possible, which fulfil some defined criteria.

The regulation set requirements for

- Basic requirements for health, safety and the environment
- Management of the petroleum activates
- Emergency preparedness
- Material and information
- Special offshore provisions pursuant to the working environment
- Design and outfitting of facilities and conducting activities in the offshore petroleum activities
- Offshore safety zones

In designing a facility some of the requirements given in the Facility Regulation confer with requirements given in the Management Regulation, /11/, the Frame Regulation,/10/, and the Activities Regulation,/12/. The PSA has however developed guidelines for all these regulations where reference to standards is given.

The Frame Regulation specify when the responsible party makes use of a standard recommended in the guidelines to a provision of the regulations, as a means of complying with the requirements of the regulations in the area of health, safety and the working environment, the responsible party can normally assume that the regulatory requirements have been met, /10/.

The regulations' guideline has a reference list which give an overview of all standards referred to in the guideline. The Facility Regulation's guideline, /13/, refers to standards and guidelines from recognised societies, including:

- American Petroleum Institute (API)
- DNV
- EEMUA (Engineering Equipment and Material User Association)
- European Standard (EN)
- IEC (International Electrotechnical Commission)
- The International Marine Contractors Association (IMCA)
- International Maritime Organisation (IMO)
- International Organization for Standardization (ISO)
- Norwegian Standards (NS)
- NORSOK standards
- Nordtest (NT)
- Norwegian Oil and Gas Association
- Oil & Gas UK
- The Norwegian Shipowners' Associations (NR)

5.1.2 Regulatory requirements for design and operation of mobile units

To fulfilling the maritime safety regulation for design and operation of mobile offshore units (MOU) the units need to have:

- Class certificate: mandatory with main class notation and POSMOR/16/ notation
- A certificate documenting fulfilment of National Maritime Authority requirement (Flag state)1: MODU code or SOLAS convention, and potential other statutory requirements
- Potential requirements from national authorities where the unit is to operate

If Norway is chosen as flag state the MOU need to fulfil the Norwegian Maritime Authority's (NMA) requirements for MOU's given in the "Rødboken", /17/. These requirements differ some from the MODU code and the SOLAS convention.

If MOUs registered in a national ship register (flag state) is to participate in petroleum activities on the Norwegian continental shelf the unit must have an acknowledgement of compliance (AoC) from PSA, /14/, /15/. The AoC is mandatory for drilling units, accommodation units, FPSOs, and well intervention units.

5.1.3 Other regulatory requirements

NMA Regulation of 20 December 1991 no. 878 on stability, watertight subdivision and watertight/weathertight means of closure on mobile offshore units

[1] Based on IMO requirements

This regulation applies to mobile offshore units which are registered in a Norwegian ship register and/or are operating on the Norwegian continental shelf. It contains technical requirements related stability, watertight integrity, freeboard and weathertight closing appliances for ship shaped units, columns stabilized units and self-elevating units.

The overall safety level in the regulation is regarded as more stringent compared to DNV-OS-C301/IMO MODU Code as larger damage extents and additional reserve buoyancy requirements for columns stabilized units may apply.

Limitations:

The reserve buoyancy requirements (§22) for column stabilized units may be difficult to comply with as it will require a deck box of a certain volume which may not be feasible for fish farms and like the DNV-OS-C301 standard this regulation may not prevent fish escape.

Regulations on Machinery / Forskrift om maskiner (Maskinforskriften) – FOR-2009-05-20-544

Applicable for all types of lifting equipment. The regulations provide essential health and safety requirements (EHSR) for the design and construction of machinery (including lifting equipment) addressed towards manufacturers, or other economic operators in the supply chain, such as importers or retailers when the equipment is imported from outside the European Economic Area (EEA).

The regulations are based on the European Machinery Directive 2006/42/EC, hereafter referred to as MD, and the requirements are thereby harmonized with other members of the EEA.

The EHSR are functional requirements, for which the current technical state of the art defines the expected safety level.

Regulations on Machinery (MD) are equally applicable for permanently placed offshore facilities (both bottom fixed and floating) as for general industry onshore. These regulations are however excluded for mobile offshore units.

The Facilities Regulations (Innretningsforskriften) - FOR-2010-04-29-634 i

Applicable for lifting equipment, when it is not subject to provisions of MD. These regulations provide functional requirements to facilities (including lifting equipment) addressed towards the responsible company, normally the operator or rig owner. The following sections are applicable for lifting equipment:

- §13 Materials handling and transport routes, access and evacuation routes
- §69 Lifting appliances and lifting gear

The responsible company may utilize recognized standards as a means of complying with the regulations. Such standards are referenced in the guidelines to the regulations

Forskrift om kran og løft på flytbare innretninger) - FOR-2017-12-21-2381

Regulations on cranes and lifting operations on mobile offshore units. These regulations are applicable for the design, construction and certification of offshore cranes and deck cranes on Norwegian mobile offshore units (carrying Norwegian flag).

The regulations provides reference to national/international standards or standards provided by MOU Classification Societies, in addition to particular NMA owned requirements within the regulations. MOU Classification Societies mentioned in the regulations are:

- American Bureau of Shipping (ABS)
- DNV
- Lloyd's Register of Shipping (LR)

NMA has also issued regulations for cranes on board ships, but they are not considered here du to the similarity of mobile offshore units with offshore ocean farming plants.

Regulations of 1 July 2014 No. 955 concerning radiocommunication equipment for Norwegian ships and mobile offshore units

This regulation gives GMDSS radio requirements for cargo ship, passenger ship and mobile offshore units. It also describes requirements for non-self-propelled mobile offshore units. The regulation refers to several SOLAS regulations and the requirements of MODU Code (Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009) No. 11.4 and 11.5. The regulation gives exemption based on trade areas defined by NMA.

Regulations of 2 February 2016 No. 90 on evacuation and life-saving appliances on mobile offshore units

This regulation gives requirements for among others radio life-saving appliances like Two-way VHF radiotelephone apparatus and Search and rescue locating devices.

Regulations of 31 January 1984 No. 227 on precautionary measures against fire and explosion on mobile offshore units,

This regulation gives requirement for internal communication equipment like two-way voice communication and public address system

Limitations:

The requirement for General emergency Alarm (GA) is not clear, but it is defined a life boat alarm.

Regulations of 1 July 2014 No. 1019 on life-saving appliances on ships

This regulation defines requirement for General emergency alarm system, Public address system, Two-way VHF radiotelephone and Search and rescue locating devices. The regulation defines also requirements for ship less than 500 gross tonnage and manned barges. This regulation may be used to cover parts of Regulations of 2 February 2016 No. 90 and Regulations of 31 January 1984 No. 227

Limitations:

The regulation does not cover two-way voice internal communication.

5.2 Discipline relevant standards

Relevant standards for the different disciplines assessed applicable for offshore fish farming units is described. The standards are used in other industries to ensure acceptable safety level for personnel and asset. This not an exhaustive list, however effort is made to include standards that are commonly used in Norwegian waters.

It should be noted that where standards from classification societies are referenced, only DNV standards are listed. Other classification societies like ABS, Loyd's Register and Burau Veritas have similar standards that may be relevant.

5.2.1 Structure - steel

Steel structures – Offshore standards

The most relevant DNV offshore standards for design of offshore steel structures which are referenced in DNV-RU-OU-0503 are listed below.

DNV-OS-C101 Design of offshore steel structures, general - LRFD method
DNV-OS-C201 Structural design of offshore ships – WSD method

These documents are DNV's offshore standards for design of general steel structures covering structural design principles and requirements for offshore structures using LRFD (Load and resistance factor design)- and WSD (Working stress design) methods, respectively. DNV-OS-C101 is primarily intended to be used in design of a structure where a supporting object standard exists but may also be used as a standalone document for objects where no object standard exist. DNV-OS-C201 also includes requirements for specific unit types, i.e. the object specific requirements are included in this standard.

DNV-OS-C102 Structural design of offshore ships-shaped and cylindrical units

DNV-OS-C102 cover structural design of mono-hull ship-shaped and cylindriacla units, and are in large degree referring to DNV-RU-SHIPS Pt.3 (Ship Rules). DNV-OS-C102 ensures that offshore specific design considerations are allowed for. The Ship Rules are following a prescriptive approach to simplify design calculations. The standard is mainly following a WSD design philosophy and is internationally recognized.

Limitations:

The standard is applicable for specific geometric hull shapes, and direct calculations is required for design.

DNV-OS-C103 Structural design of column-stabilised units - LRFD method
DNV-C104 Structural design of self-elevating units - LRFD method
DNV-C105 Structural design of TLPs - LRFD method (when applicable)
DNV-C106 Structural design of deep draught floating units - LRFD method

Object specific standards covering structural design of column-stabilised units, Self-elevating units, TLP's (tension leg platforms), and deep draught floating units.

DNV-OS-B101 Metallic materials

International standard for quality of metallic materials used for offshore construction and fabrication by defining minimum requirements for material specifications, treatment processes and testing.

DNV-OS-C401 Fabrication and testing of offshore structures

International standard giving the minimum requirements for fabrication of offshore units, installations, and equipment by welding, including requirements for mechanical fastening, testing and corrosion protection systems.

Steel structures – NORSOK standards

The most relevant NORSOK standards for design of offshore steel structures which are referenced in the Facilities Regulations are listed below.

NORSOK N-001:2020 Integrity of offshore structures

The NORSOK standard N-001 generally refers to NS-EN ISO 19900 which contain general requirements for offshore structures for the NORSOK set of standards and in particular the partial safety factor method (also called the LRFD method)

NORSOK N-003:2017 Actions and action effects

The standard specifies general principles and guidelines for determination of characteristic actions and action effects for design, assessment and verification of structures. Reference is made to NORSOK N-001 as to how this standard is to be used to achieve the desired safety level for new and existing structures.

NORSOK N-004:2022 Design of offshore structures

The standard specifies guidelines and requirements for design and documentation of offshore structures and is applicable to all type of offshore structures made of steel with a specified minimum yield strength less or equal to 500 MPa.

NORSOK M-001 Material selection

The standard provides guidance and requirements for material selection and corrosion protection for hydrocarbon production and processing facilities and supporting systems for fixed offshore installations including subsea production systems. The standard also applies for onshore terminals, except for structural and civil works. The basis for material selection and corrosion protection in this document is minimum 20 years design life.

NORSOK M-101 Structural steel fabrication

The standard covers requirements for fabrication and inspection of offshore steel structures with SMYS < 500 MPa and with a minimum design temperature down to -140C.

NORSOK M-120 Material data sheets for structural steel

The standard includes a collection of material data sheets (MDS) applicable for selected material standards and grades for use in steel structures.

NORSOK M-122 Cast structural steel

This standard defines the requirements for qualification of foundries and the technical delivery requirements for cast structural steel for use in offshore structures where Steel Quality Level I or II is required.

NORSOK M-123 Forged structural steel

This Standard defines the requirements for qualification of forges and the technical delivery requirements for forged structural steel components for use in offshore structures where Steel Quality Level I or II is required.

5.2.2 Structure - Concrete

DNV-ST-C502 Offshore concrete structures

DNV-ST-C502 is an international standard used for design of offshore concrete structures. The standard is prepared based on more than 40 years of industry experience with offshore concrete structures and the standard is suitable for design for both fixed and floating offshore concrete structures.

The design format within DNV-ST-C502 is based upon a limit state and partial safety factor methodology, also called load and resistance factor design format (LRFD).

NS3473.E Concrete structures - Design and detailing rules

NS3473.E, was widely used in the design of fixed offshore concrete structures and was recognized as meeting the requirements of reference standard for concrete design

NS3473.E is suitable for design of both fixed and floating offshore concrete structures.

The design format within NS3473.E is based upon a limit state and partial safety factor methodology, also called load and resistance factor design format (LRFD).

Limitations:

As part of the Eurocode programme in Europe, NS3473.E was withdrawn and replaced with Eurocode 2 and may cease to be suitable as a reference standard in the future. However, any standard can be used as a reference standard provided that is supplemented by additional requirements, where necessary, to ensure that all relevant aspects for the design are properly covered within a consistent safety level. On the other hand, NS3473.E presents the challenge that it is not being maintained or updated.

NS-EN 13670:2009 +NA:2010 Execution of concrete structures

The referenced execution standard in NS 9415:2021 is NS-EN 13670. NS-EN 13670 gives a good framework for execution works. The standard heavily relies on a suitable project specification in terms of scope and detail.

5.2.3 Structure - Composite

DNV-ST-C501 Composite components

This standard is an international used standard for verification of composite structures. It is applicable to all products and parts made of fibre-reinforced plastic composite material and may be applied to modifications, operation and upgrading made to existing ones. Emphasis with respect to loads and environmental conditions is put on applications in the offshore and processing industry. The material description and calculation methods can be applied to any application, including fish farm installations at sea and on land.

This standard gives the possibility to design structures or structural components with different structural safety requirements, depending on the safety class to which the structure or part of the structure belongs. Structural reliability of the structure is ensured using partial safety factors that are calibrated to meet given target structural reliability levels.

The design equations are formulated in the LRFD format.

NS9415:2021 refers to DNV-ST-C501 for requirements on composite material properties.

Limitations:

Loads are not defined in this standard. Partial load safety factors are however defined for offshore applications.

DNV-ST-B302 Effects of the Environment on Mechanical Properties of Polymers and Composite Materials

This standard is a new international standard used for verification of environmental effects on polymers and composites. The standard describes how the mechanical properties of polymers and composites are influenced by time, temperature and exposure to fluids. The guideline is written for oil and gas applications both offshore and onshore. However, most aspects described are generic and can also be applied to other applications, like aquaculture and environmental effects of seawater.

The standard provides methods to describe mechanical properties short-term strength, long-term stress rupture and fatigue properties including elastic moduli, creep and stress relaxation of polymers and unidirectional (UD) plies (fibre reinforced plastics) with respect to time dependence (including strain rate - loading rate) temperature dependence, presence of an absorbed fluid influence of possible chemical reactions with the fluid, influence of possible mechanical damage (fibre-matrix debonding) due to fluid.

This standard gives the possibility to qualify composite materials and polymers for structural components with different structural safety requirements, depending on the safety class to which the structure or part of the structure belongs.

Limitations:

The scope is limited to carbon and glass fibres. The first edition of the standard will be released in the autumn of 2022.

5.2.4 Stability

DNV-OS-C301 Stability and watertight integrity

DNV-OS-C301 is an international offshore standard (OS) used for classification which provides principles, technical requirements and guidance related stability, watertight integrity, freeboard and weathertight closing appliances for various types of mobile offshore units and floating offshore installations.

The stability requirements in the OS are based upon and cover the requirements of the IMO 2009 MODU Code Ch.3, but with additional interpretations and clarifications included.

The type of units covered by the standard are ship-shaped units, column stabilized units, self-elevating units, cylindrical units, tension leg units and deep draught units.

Limitations:

The standard is limited to ensure that the unit has sufficient stability to stay afloat under harsh environment or after being subject to collision or flooding damages. Hence, fish farms that adopt this standard may need additional requirements to prevent fish escape.

5.2.5 Anchoring, mooring and towing equipment

DNV-OS-E301 Position mooring

Contains criteria, technical requirements and guidelines on design and construction of position mooring systems, as well as technical requirements for mooring and towing equipment. Applicable for floating bodies relying on catenary mooring, semi-taut and taut leg mooring. Requirements to specific mooring materials and components (such as anchors, mooring chain, fibre and steel wire) are referred to within this standard.

Limitations:

The standard is applicable and limited to column-stabilized units, ship-shaped units single points moorings, loading buoys and deep draught floaters (DDF) or other floating bodies relying on catenary mooring, semi-taut and taut-leg mooring.

ISO 19901-7 Petroleum and natural gas industries — Specific requirements for offshore structures

Specifies methodologies for a) the design, analysis and evaluation of station keeping systems for floating structures used by the oil and gas industries, b) the assessment of station keeping systems for site-specific applications of mobile offshore units. Applicable for spread moorings, single point mooring, dynamic position systems, and thruster-assisted moorings. Contains regional clauses for offshore Norway.

Limitations:

The standard is mainly applicable for oil and gas applications.

5.2.6 Lifting equipment

The term lifting equipment generally comprises following types of equipment:

- Lifting appliances (cranes, winches, hoists etc.). Lifting appliances may be both fixed (permanently installed) on an asset, mobile or transportable;
- Lifting accessories (slings, shackles etc., which are not integral part of lifting appliances, but normally suspended from the hook of a lifting appliance to hold a load);
- Other work equipment with integrated work platform to lift or transport personnel.

National regulations in Norway addresses safe design and construction of lifting equipment, as well as safe use and operation of lifting equipment. In this document, only requirements for safe design and construction are addressed. There are several regulatory regimes covering lifting equipment, depending on the industry in which the equipment is used. Relevant standards from these are given below:

General industry onshore

European Machinery Directive (MD) provides the manufacturer with an option to utilize harmonized standards when designing and constructing lifting equipment and other machinery. Application of harmonized standards provides for presumption of conformity with the Essential health and safety requirements (EHSR) of MD. Harmonized standards are developed and issued by the European Standardisation Committee (CEN), and approved by the European Commission as means to comply with MD. Currently there is a wide range of different types of lifting equipment for which a harmonized standard has been issued. For complete overview of harmonized standards under MD, reference is made to this web page: https://ec.europa.eu/docsroom/documents/49995. Some examples of harmonized standards for lifting equipment are mentioned here:

- EN 12999: Cranes - Loader cranes
- EN 14985: Cranes - Slewing jib cranes
- EN 13852-1: Cranes - Offshore cranes - Part 1: General-purpose offshore cranes
- EN 13852-3: Cranes - Offshore cranes - Part 3: Light offshore cranes
- EN 818-4: Short link chain for lifting purposes - Safety - Part 4: Chain slings - Grade 8
- EN 13414-1: Steel wire rope slings - Safety - Part 1: Slings for general lifting service

Limitations

Certification requirements are limited. Normally the proof of compliance is the Declaration of Conformity and CE-marking provided by the manufacturer. Involvement of a Notified Body may be required for devices for the lifting of persons, but Notified Body is not involved in the production of each produced unit

Requirements for fabrication are limited in MD. Most requirements are related to the design.

Petroleum industry offshore (and onshore)

NORSOK R-002 Lifting equipment

Currently the main reference to recognized standard for lifting equipment is in the guidelines to the Facilities Regulations.

This is a comprehensive standard in terms of different types of lifting equipment used on board offshore facilities. It covers both design and fabrication, as well as certification requirements by Enterprise of Competence. The standard utilizes the safety principles of MD and makes reference to most applicable harmonized standards. It also contains additional requirements particular for the Norwegian offshore petroleum industry.

Limitations:

Note that MD is not applicable for MOUs following maritime regulations.

Maritime sector

The following standards are referenced as applicable within the Regulations on cranes and lifting operations on mobile offshore units:

Offshore cranes:

EN 13852-1:2013, General-purpose offshore cranes

DNV-ST-0378 Standard for offshore and platform lifting appliance (or a standard with an equivalent level of safety from another MOU classification society)

Deck cranes:

Recognised standard issued by:

- NS/EN/BS/API/DIN/NFPA/ISO/CEN/IEC. (Alternatively, a standard issued by an equivalent standardisation body may be used)
- an MOU classification society

Loose lifting equipment (lifting accessories)

NORSOK R-002 Annex C, for deck cranes

NORSOK R-002 Annex C and F, for offshore cranes or a standard with the same scope and level of safety

5.2.7 Communication

DNV-OS-A101 Safety principles and arrangement, Ch.2 Sec.5

This rule set covers two-way voice communication, General emergency alarm and Public address system. It refers to SOLAS Ch.IV or MODU Code Ch.11 for external communication.

Limitations:

The rule set does not cover life-saving appliances like Two-way VHF radiotelephone apparatus and Search and rescue locating devices.

DNV-RU-SHIP Pt.6 Ch.3 Sec.1 or Sec.2 for additional notation DYNPOS depending on DYNPOS qualifier

If the unit shall have a DP solution, this requirement which also includes some additional requirements for internal communication should be considered.

NORSOK T-003 Telecom systems for mobile offshore units (MOU) (2019)

Provides a set of minimum requirements following best practices for telecom and IT systems that have sufficient capacity and security to match the requirements of the company contacting the vessel.

5.2.8 Navigation

Norwegian Coastal Administration (NCA) – Provisions related to the marking of permanently located offshore units in the petroleum industry dated 20 December 2013. (Rev.1, 22 January 2018.)

These provisions specify requirements for marking of offshore units for them to be quickly identified such that other traffic in the area is notified at a distance that is sufficient for other vessels to choose a safe course for passing.

IALA GUIDELINE - G1162 - "The Marking of Offshore Man-made Structures" (Ed.1.1 Dec. 2021).

These guidelines cover inter alia marking of Offshore structures and applies to all structures fixed in position temporarily or permanently which extend above or below the surface of the sea and which are obstructions to navigation. (Replace IALA's Recommendation O-139 on the "Marking of Man-Made Offshore Structures" referred to in NCA's provisions above.)

Convention on the International Regulations for preventing collisions at sea (COLREG), 1972 as amended.

COLREG specifies inter alia requirements for lights, sound signals and shapes for vessels underway, at anchor and vessels being towed.

Limitations:

Requirements will depend on whether the vessel is self-propelled or towed.

Norwegians Maritime Directorates Regulations of 5 September 2014 No. 1157 on navigation and navigational aids for ships and mobile offshore units. (As amended 28 June 2022.)

These regulations apply inter alia to mobile offshore units and specifies i.a. requirements for bridge design, carriage requirements for navigational systems and equipment, navigation bridge visibility and pilot transfer arrangements.

Limitations:

Requirements will depend on whether the unit is self-propelled or not.

5.2.9 Marine Systems

DNV-OS-D101 Marine and machinery systems and equipment

DNV-OS-D101 is DNV offshore standard for marine and machinery systems and equipment. DNV-OS-D101 provides principles, technical requirements and guidance related marine and machinery systems and equipment.

The systems covered by the standard are ballast, bilge, drainage, air, overflow, sounding and storage and transfer of liquids with low flashpoint (e.g. helifuel), cooling systems, lubrication oil, fuel oil and hydraulic systems.

The standard covers general piping design, platform systems, machinery piping systems, machinery and mechanical equipment, piping fabrication, workmanship and testing, in addition to DNVs certification requirements.

Limitations:

The general piping section may be applied to all piping systems also those not specified in the standard. The machinery system section is primarily applicable for units with propulsion, where machinery is a main function. The platform piping part is aimed for units with tanks that provide buoyancy but may also be applied for other designs.

NMA Regulation of 27 January 2016 no. 67 on ballast systems on mobile offshore units (Ballast Regulations)

This NMA regulation, ballast systems on mobile offshore units, applies to mobile offshore units which are registered in a Norwegian ship register and/or are operating on the Norwegian continental shelf. It contains technical requirements to capacity and operation of ballast systems for ship shaped units, columns stabilized units and self-elevating units.

The overall safety level in the regulation is regarded as more stringent compared to DNV-OS-D101 as larger capacity and more redundancy requirements especially for columns stabilized units may apply.

Limitations:

The regulation is mainly applicable for units where ballast system is critical for stability.

5.2.10 Fire safety

DNV-OS-D301 Stability and watertight integrity

DNV-OS-D301 is DNV offshore standard for fire protection.DNV-OS-D301 provides principles for design, installation and commissioning of fire protection of mobile units and offshore installations. It covers passive fire protection, active fire protection, fire-fighting systems, fire and gas detection and alarm and escape systems.

Limitations:

This standard is applicable for fish farming units that are column-stabilised, cylindrical and self-elevating design.

The standard are mainly focused on manned units where sufficient trained personnel are available for manual firefighting. For fish farms with less or no manning other means of fire protection/firefighting needs to be evaluated.

The areas of fire risk may be different on a fish farming unit than on an offshore unit hence the use of the regulations may need evaluations.

DNV-RU-SHIP Pt.4 Ch.11

DNV-RU-SHIP Pt. 4 Ch.11 is part of the DNV ship requirements for fire safety. It covers passive fire protection, active fire protection, fire-fighting systems, fire detection and alarm and escape systems.

The code differentiate between cargo ships below 500 gross tonnage(gt) and cargo ships above 500 gt and passenger ships. For cargo ships above 500 gt the code refer to SOLAS Ch. II-2 for technical requirements.

It is the requirements for cargo ship above 500 gt that has been considered most applicable for fish farming units.

SOLAS Ch. II-2 (cargo ship requirements)

SOLAS Ch. II-2 is the fire safety part of the international requirements for ships. The requirements cover fire protection, fire detection, fire extinguishing and escape.

The code differentiate between passenger ships and cargo ships. The cargo ship requirements has been considered most applicable for fish farming units.

Limitations:

The code are focused on manned ships where sufficient trained personnel are available for manual firefighting. For fish farms with a lower or no manning other means of fire protection/firefighting needs to be evaluated.

The areas of fire risk may be different on a fish farming unit than on a conventional ship, hence the regulations may need evaluation.

NMA Regulation of 1 July 2014 no. 1099 on fire protection on ships

This NMA regulation, on fire protection on ships, differentiate between cargo ships below 500 gross tonnage(gt) and cargo ships above 500 gt. It is considered that the part for cargo ships above 500 gt is most applicable, and his section refers to SOLAS Ch. II-2 which is mentioned above.

5.2.11 Life-saving appliances

NMA Regulation of 1 July 2014 no. 1019 on life-saving appliances on ships

NMA Regulation of 1 July 2014 no 1019 on life saving appliances on ships refers SOLAS Ch. III for cargo ships above 500 gt which are the rules that has been considered the most applicable for fish farming units.

SOLAS Ch. III Life-saving appliances and arrangements

SOLAS Ch. III is the international maritime regulations for lifesaving appliances and arrangements. It covers emergency communication, personal life saving appliances, survival crafts, rescue boats and evacuation arrangement.

It is the cargo ships rules that has been considered most applicable for fish farming units.

Limitations:

A minimum number of trained crew is needed to be able to operate life-saving appliances.

On fish-farming designs persons could fall into the water inside the cage, this is a scenario that is not covered by the rules as requirements for survival crafts are covering evacuation from the unit.

NORSOK R-002:2017 Lifting equipment

This NORSOK standard is valid for technical requirements to lifting appliances and lifting accessories on all fixed and floating installations, mobile offshore units, barges and vessels, as well as on land based plants

where petroleum activities are performed. This standard is also valid for material handling and the following equipment:

- Launching and recovery appliances for life saving equipment, with and without lifting function;
- Means of connection and release systems that are integrated parts of life saving equipment, as well as their anchorage in the life saving equipment;
- Portable units;
- Foundations and suspensions for lifting appliances;
- Lifts.

6 RESPONSE FROM INDIVIDUAL INTERVIEWS

This section covers response received in interviews with relevant parties in the aquaculture industry as authorities, designers and fish farmers. In total, 15 persons from 9 different organisations have been interviewed with one interview per organisation. The interviews are made under the premise that all response is anonymous.

The statements referenced in the below section are meant to cover the main message received in the meetings and may give an overview of important issues that should be covered in discussions related to regulations for offshore aquaculture.

Revision 0 of the technical memo will be issued later with additional content based on the meeting in “Responsible innovation lab” 7th of October.

Interview format

The interview is performed via Teams and interviewer have been Ragnar Tveterås (UiS) and Frode Kamsvåg (DNV). The interviews have focused on the following themes:

- Today’s knowledge status about safety for construction and crew for aquaculture at sea? Benefits? Cons? Uncertainties?
- Knowledge building: In which areas do we need more knowledge, and how are we going to get this knowledge?
- Administration and regulations: To what extent are adaptations/changes/new laws and regulations needed for aquaculture at sea? What changes? Changes in management?
- Innovation: What innovations in plant technology and operation of facilities for aquaculture at sea are necessary to ensure a proper level of safety for the facility and crew?

An interview guide has been used in the interviews, but focus has been on allowing the interviewees to talk about possibilities and challenges related to HTH and their thoughts about the way forward. What advice do they have on how to manage HTH in the future, both regulatory wise and in practice and what concerns need to be addressed?

6.1 Response from individual interviews

6.1.1 Introduction

As mentioned above, the interviews are made under the premise that all response is anonymous. Notes from the meetings, together with recordings from the interviews are used to get the meaning and intension behind the answers

correctly referenced. However, the answers are mixed below each theme and there is no sorting on believed importance or impact of the different statements.

The below statements are sorted according to some common themes. Many of the statements could be sorted under more than one theme. We have tried to use the most relevant theme but have probably not managed this for all statements.

Since we performed quite many interviews, some statements may seem to be repeated. We have chosen to do this instead of condensing it to only one statement.

The response is sorted according to the following themes:

Regulations

General thoughts related to basic building blocks for new regulations for HTH. How should this be built up, what should it include, how to include different risks, etc.

Specific comments on existing regulations and their fit for the new industry.

HSE

General comments around important issues for HSE.

Specific comments on existing regulations and their fit for the new industry.

Competence

General thoughts about important issues related to the competence onboard the installation.

Innovation needs for the industry when moving offshore.

Risk/safety

Comments about today's safety management and needs for the future

Regulatory bodies

Comments about the relevance and suitability of the different regulatory bodies for HTH.

Accreditation/verification/Class

Comments related to relevance of the different assurance parties and challenges related to assurance of design.

Owners and designers

Important issues for owners and designers when going offshore.

6.1.2 Statements related to regulations:

General comments

Barrier thinking should be used in regulations, meaning that the risk level must cover the totality, i.e. local damage must not escalate.

It should be more focus on sharing challenges openly at an early stage to find solutions before it escalates instead of focus on fines when something has happened. This may provide learning for the entire industry.

Recognised international Class rules should be used, not specifical Norwegian accreditation schemes.

There should be a competition on each offshore field available where the winner may present a “PUD” to the authorities, similar as for the petroleum industry. MTB should be for a larger area such that there is no need to apply for each new locality.

Important to remember that the purpose is to grow fish in a sustainable way. Must include safety aspects related to fish welfare and knowledge of interaction between fish, biomass, construction.

Today fish is more important than personnel. Need systems that reduce consequences without people sacrificing their safety.

Safety level should be adapted to other industrial activities at sea which is a different level than in sheltered waters. The size of biomass, people on board, etc. lead to stricter requirements.

Regulations should be “technology neutral” allowing for innovations.

This is industrial activity at sea and must be regulated as such.

Lack of clearly defined safety level creates extra work and evaluations.

Regulations should cover innovative concepts.

Equipment must be adapted to maritime challenges.

Create new regulations with functional requirements and guidance notes with reference to existing requirements that are relevant.

Cannot make a cookbook which means that more responsibility falls on the actors.

Must think more broadly than fish escape.

For HTH, we have to design for accidental conditions and "worst case" with clear risk acceptance criteria. We must look at more than fish escape, e.g. collision (what should the net withstand?).

Standardization - need to agree on some methods/standards that can be used on all types of installations. This applies to pre-equipment, silage etc. which also is important for the cost level.

Regulations for transport of people need to be included.

Use of maritime equipment or offshore equipment is balance between CAPEX and OPEX cost. Maritime is low in CAPEX but more costly in OPEX.

Should look to offshore experience but requirements must be tuned to fish farming.

Use of class and NMA gives a holistic human and technical safety level.

Proposal for regulations for aquaculture at sea states a time limit of 25 years. This gives possible suboptimization which is not necessarily good. It is assumed that lifetime extension will be possible.

Until unified regulations exist, guidelines with overview of acceptable combination of existing regulations/standards should be published.

Would be beneficial with an overview of all relevant regulations for the industry.

It is important to see requirements as part of a larger context where HTH includes the total value chain from smolt to fish delivered for slaughtering and where HSE and technical requirements influence each other.

Operational plans and HSE should be important already early in the allocation process.

Life and health are more important than fish escape.

Regulations should be functional based, not prescriptive.

Today’s standards will not be sufficient tomorrow, hence constant development is needed.

Specific comments

Nytek/NS 9415 is Relevant for what it covers - other standards will be more relevant for other areas.

Uncertain whether what is specific to aquaculture at sea is taken into account when an existing set of regulations is applied directly.

Don't want to adopt offshore security philosophy which is evaluated to be overkill.

Stability requirements from NYTEK/NS 9415 are not sufficient.

The “Working Environment Act” does basically not apply for “shipping, catching and fishing", i.e. is not sufficient for HTH. Does not take into account that you are at sea.

Most movable installations according to the Petroleum Act use a maritime regime.

Cheaper to build to standard regulations compared to PTIL function-based requirements, leading to high cost.

If we want to mass produce also for other countries, maritime regime that is used all over the world should be used. This makes it easier to sell abroad.

Maritime approach is relevant for steel constructions and IMO 1455 describes the process for alternative designs and specific standard to follow. Function in the Ship Safety Act which states that this must be safe.

Important to coordinate between agencies, e.g. if you meet maritime stability requirements this should be equivalent to meeting stability requirements in NS9415.

NYTEK applies for offshore but is based on empiric and traditional facilities and is too narrow for HTH.

NYTEK/NS 9415 is relevant also for HTH but must be part of a larger context.

Stability requirements in NS 9415 are irrelevant for many offshore structures.

Maritime regime is based on detailed requirements while PTIL is more modern with functional requirements. There is learning from O&G but fear of cost spiral should be taken seriously.

Most concepts are not like a ship where we have hundred years of experience with response behaviour and that can be brought to yard for repair. Need to look to O&G experience.

Regulations need to be relevant for the given concept. If offshore like, offshore standards should be used If ship shaped, maritime may be used (much simpler).

There is a tendency to focus more on technical requirements than HSE issues for the workers in the maritime regime.

The most similar thing to HTH is the petroleum industry minus the risk of major accidents.

6.1.3 Statements related to HSE:

General

Related to HSE, it is important to take into account that the waiting time to get help can be long.

There should be standardization related to HSE issues, i.e. clear guidelines.

HSE regulations need to be functional based.

HSE must be elevated to be as important as fish escape and the external environment.

HSE culture in fish farming need to be changed from evaluations made at site to accept criteria (barrier management) made in beforehand.

Distances are important. How does the authority open up, standby time, transporting people for medical attention etc. The longer distances influence the level of self-sufficient needs.

Base case regulations

The Working Environment Act should apply with one coordinated supervisory activity. Shift arrangements may have regulatory/operational consequences.

For HSE, shipping is specially regulated because it has many special features. HTH is more like petroleum business.

The starting point should be the regulations in the Working Environment Act and then use special regulations for HTH in order to adapt (similar to what has been done for offshore wind).

6.1.4 Statements related to competence:

General

Manning from maritime industry is key to keep safety onboard and follow up marine systems. Many systems that need to be followed up during operation. Stability and ballasting of special importance.

There should be mechanisms that ensures that maritime competence/certificates can be maintained. It is difficult now as the Ship Safety Act is not followed.

Maritime competence is important for safety, maintenance, stability (ballast), fire, evacuation, etc.

There should be some requirements to qualifications for the crew.

In maritime industry there is competence/certificate requirements to personnel while it is not so in fish farming. Should this be coordinated?

Educations need to be adjusted to ensure that competence is developed in parallel with technology development.

The supplier in the fish farming industry need to develop to be able to deliver to international projects (build internationally). This means that they need to build engineering capabilities.

Innovation needs

Should show that new technology functions as intended. Possible means is technology qualification.

We meet new challenges for HTH, also for traditional fish farming equipment as the net. We need to build new competence also for net.

Is net knowledge for traditional farms relevant for HTH? E.g. lifetime, material factor, environment, shielding, dynamics, drag, load factors, etc

It should be possible to detect damages automatically.

We need to develop new methods to avoid harming the fish due to growth in seawater systems.

Fish farming equipment sufficient for traditional fish farms may not be suitable for HTH. This may lead to high lifetime expenses due to more follow-up in operation.

Will water quality in large farms, especially during operations with crowded volumes, be acceptable?

How to empty a facility. In a fjord you can have the same amount of biomass, but weather and the number of available boats can create greater problems with emptying the facility and avoiding fish deaths for HTH.

Heavy sea shall not stop work onboard. New concepts have to take this into consideration.

6.1.5 Statements related to risk/safety:

There is a safety culture in the industry which means that risk is not handled well enough. This need to be improved for HTH (and also in-shore).

The industry thinks they have a better understanding of risk than they do.

Offshore aquaculture will have other actors with resources and expertise for a better risk management system.

Risk management is not good enough today.

Must think about risk and safety in a larger context.

Need to improve preparedness and safety management, e.g. “internkontrollforskriften” need to be improved.

Worried that some concepts are built with a safety level below what should be accepted.

Should safety level depend on whether construction is manned or not?

Need to ensure overall safety concept (person, construction, fish, enclosure).

In reality, fish escape is not important. An example is escape of 67000 smolt from land-based farm that only create small notes in papers.

6.1.6 Statements related to regulatory bodies

There are too many public actors – The Norwegian Fisheries Directorate should be at the top with a coordinating role, NMA on safety.

The Norwegian Labour Inspection Authority should not necessarily have a direct role in HTH.

Management of the industry must be coordinated.

For HTH, there must be a coordinating authority. The Norwegian Fisheries Directorate is awarding authority and a natural choice.

Need good cooperation between agencies and utilize each other’s competence. Minimal doubling of competence.

Regulations should be managed such that you get a holistic approach and then we need government bodies not working against each other.

Important to involve NMA. Norwegian Labour Inspection Authority do not have the competence on these structures in these conditions.

Seems to be a conflict between The Norwegian Fisheries Directorate, NMA and the Norwegian Labour Inspection Authority. Someone should have made decisions by now, 5 years after the first construction is made.

NCA has bad procedural processes creating challenges.

Sometimes difficult to see where responsibility is at different regulatory bodies and there seem to be a fight between some of them.

Important that different agencies have a clear description of responsibility – clear defined borders between them.

Agencies having responsibility for HSE need to be active. I must not be parties with authority but with inability to agree on plans.

A lot of safety philosophy from O&G can be implemented, but sceptical to giving PTIL a large role – they probably need to change a lot to adapt to the fish farming reality.

PTIL is best in class when it comes to supervising according to standards.

Most facilities are currently not designed as vessels, i.e. most relevant to use PTIL based on the Working Environment Act as basis.

If the supervisory authority has a wide spectrum to follow up, the probability that there are regulations that the authority does not follow up is increased.

Different sector authorities seem to work against each other to secure their position.

Getting a well-functioning regime in place for the planning and development of HTH and that it becomes an area of focus for the supervising authority is more important than who is actually doing the supervision.

There should be one coordinating supervisory authority. The Norwegian Maritime Directorate could be a natural choice also since it also covers the vessels in the logistic chain around the fish farm. If so, they have to build it around functional requirements.

The Norwegian Labour Inspection Authority does not have the competence needed for HTH. Norwegian Maritime Directorate should be the responsible authority.

NMA need to be involved in HSE matters as it is very difficult to relate to Norwegian Labour Inspection Authority. They are not an active part in the projects and do not understand the challenges, hence it is not possible to get acceptance for plans and instead findings are issued when the project is finished.

Public agencies with "business development" may lead to compromises that lead to less optimal regulatory framework.

It is important to have clearly defined who will supervise that regulations are followed-up in operation.

6.1.7 Statements related to accreditation/verification/class

One should ensure that actors are qualified for the work. The current accreditation scheme gives small actors with limited competence to much influence.

For offshore aquaculture, accreditation should not be used. Look to O&G.

Should be an independent third party. Do not need to be a Class society.

Avoid fragmentation - need permits/mechanisms that make the holder of concessions accountable - do not rely on certification bodies.

Should be more frequent supervision of those actors who do not have sufficient competence. Focus on actors that are not meeting requirements in supervisions.

Must improve at system audits/system supervision.

Some assumed serious accredited companies and class societies lack competence and a serious attitude towards requirements to documentation on this type of constructions.

Accredited companies without the right competence and attitude related to risks in larger constructions do limited verification work at a low price – critical for the constructions.

Surprised by how easy it sometimes may be to get accreditation for an installation – if QA list is followed it is ok.

6.1.8 Statements related to owners and designers

Should be requirements to the operator of such a unit. Organisation to be prequalified.

Incidents of escapes in traditional fish farming show that there is poor management and poor communication and an immature attitude to risk. Unable to learn from events. This is primarily due to organizational reasons. This is not acceptable for HTH.

Should be more frequent supervision of those actors who do not have sufficient competence. Focus on actors that are not meeting requirements in supervisions.

There should be an allocation round for HTH with requirements for pre-qualification (HMS, safety, safety management). If you do not understand the scheme, you do not have the necessary competence.

Must be able to demand more from those going offshore.

7 RESPONSE FROM SURVEY

As part of the project, a workshop was held on 2023-02-17 with invited participants mainly from designers, operators and government agencies. This workshop was a follow-up of the individual meeting conducted with many of the same actors. While the interviews with the different actors provided many relevant inputs regarding regulations for HTH, it was at the same time difficult to consolidate this into clear advices as the interviews were conducted with a relative open agenda where the aim was to ensure that all important issues on their mind was brought up and discussed.

This workshop was therefore aiming at getting an overview of the participants views using a survey that raised questions that were deemed relevant based on the results of the individual interviews. This survey was sent to all invited actors. The following sections give an overview of the questions and responses from the survey.

Please note that the survey was performed using Norwegian language and the Questions and response from the survey are translated from Norwegian.

7.1 Participants

A total of 24 persons were invited to the workshop, 18 participated in the workshop and16 responded to the survey (including the project participant from DNV). There was mainly one participant from each company/agency in the survey, but a few had more than one participant. Categorisation of the survey participants is shown in Figure 7-1.

The number of participants is too low to give any relevant statistical evaluation,

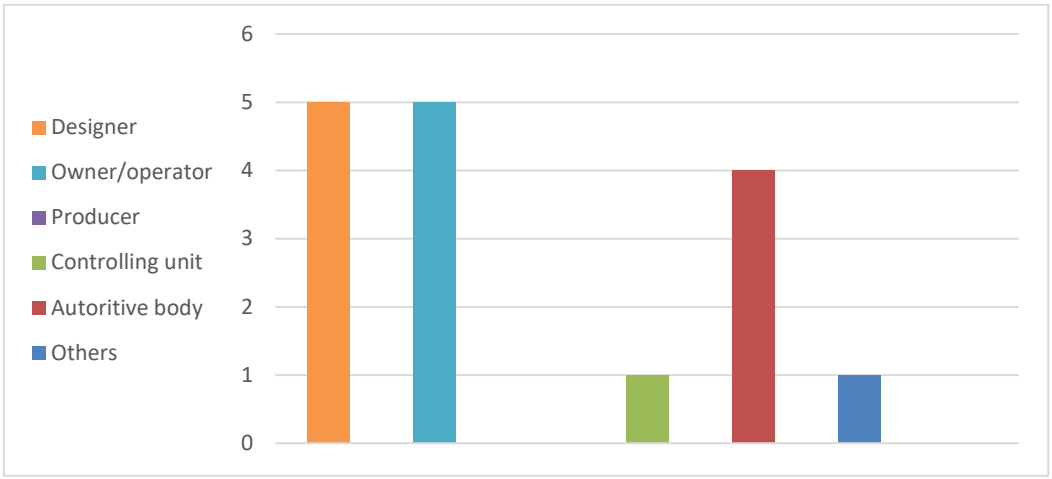

Figure 7-1 Number of persons participating in survey, distributed on type of industry player.

7.2 Safety level

The safety level in aquaculture regulations is currently quite vague and the following questions related to the safety level for HTH are asked:

- To what extent are the current regulations adapted to HTH in relation to ensuring a robust design that contributes to acceptable risk?
- To what extent is it desirable for the authorities to define safety levels for relevant items?
- What comparable level of safety should be the basis for drafting regulations for HTH?

The responses to the above questions are summarised in Figure 7-2 to Figure 7-4.

The responses indicates that today's aquaculture regulation is assessed not to be adaptable for HTH, in particular legislation related to risk for personnel and operations related to visiting vessels, see Figure 7-2. From Figure 7-3 and Figure 7-4 it is also seen that it is desirable that the authorities define a safety level for the industry. The definition of the safety level is more complex, and it is also challenging to clearly understand all differences between different regulations. However, based on the feedback it lean towards a safety level equal to the Oil and Gas industry in Norway, and with safety level minimum as in maritime business.

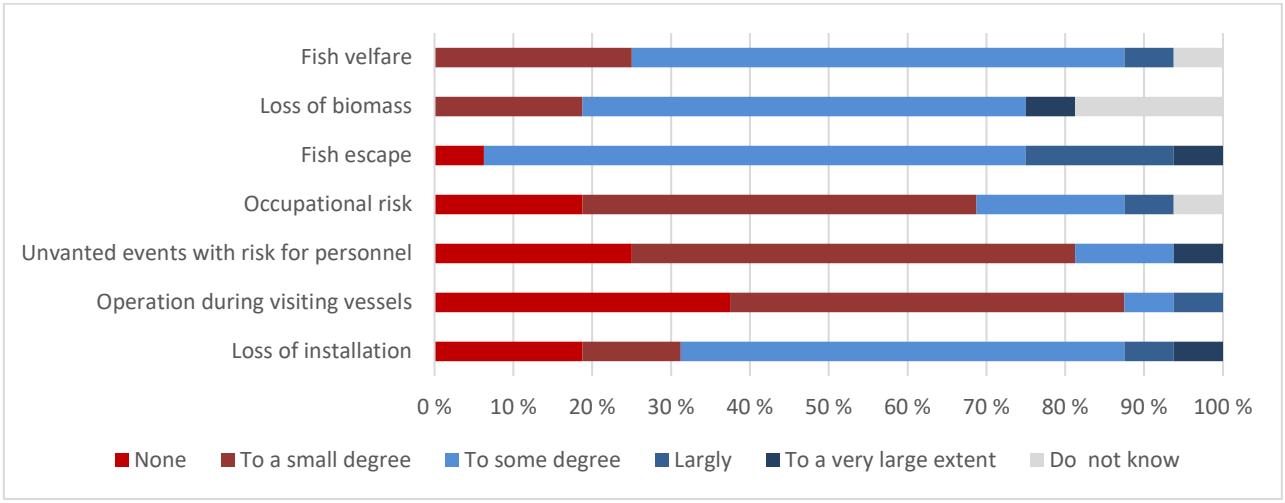

Figure 7-2 To what extent are the current regulations adapted to HTH in relation to ensuring a robust design that contributes to acceptable risk for the following? Percentage distribution of answers given in the survey.

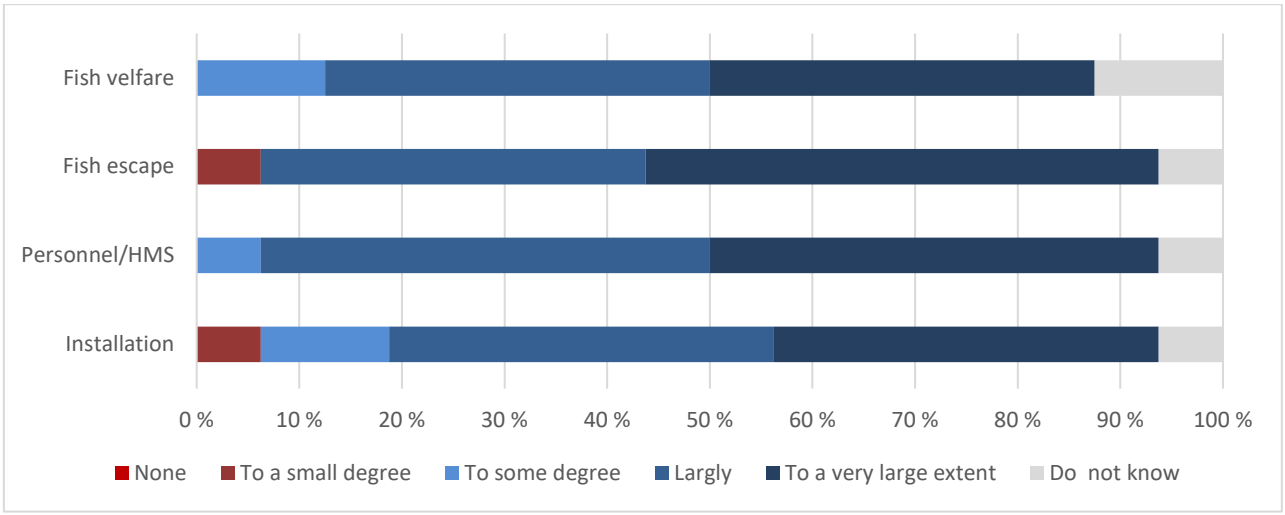

Figure 7-3 To what extent is it desirable for the authorities to define safety levels for the following? Percentage distribution of answers given in the survey.

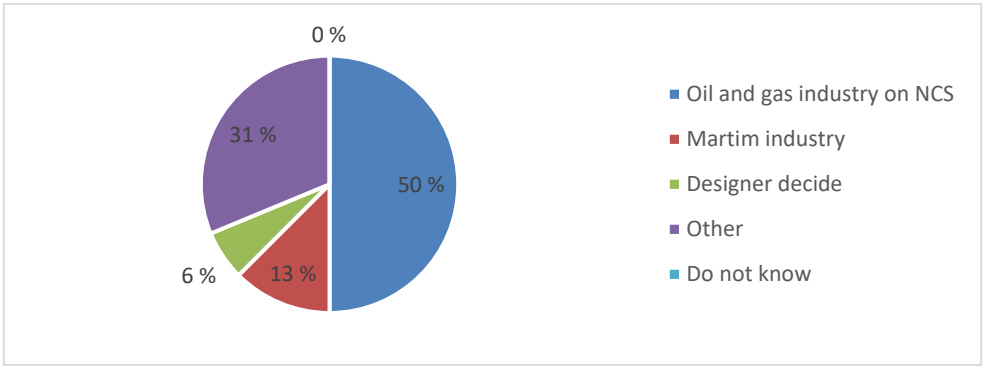

Figure 7-4 What comparable level of safety should be the basis for drawing up regulations for HTH? Percentage distribution of answers given in the survey.

7.3 Regulations

Regulations are normally labelled as function-based or prescriptive. The fish farm regulations have historically been prescriptive based but has had a shift towards more functional based approach in the latest update of Nytek NS 9415.

Participants are asked whether functional based or prescriptive regulations are preferred for HTH, both in general and if there are some special areas that should be treated differently.

According to the responses shown in Figure 7-5, Figure 7-6 and Table 7-1, it is a clear wish that regulations for HTH are functional based such that they are suited for new and innovative designs. However, prescriptive regulations are mentioned where this is possible to use due to previous relevant experience.

At the same time, the responses show that it is seen as very important that the functional-based regulations are followed-up by guidelines that describe design principles and standards/codes that define the authorities' expectations for fulfilling the functional requirements.

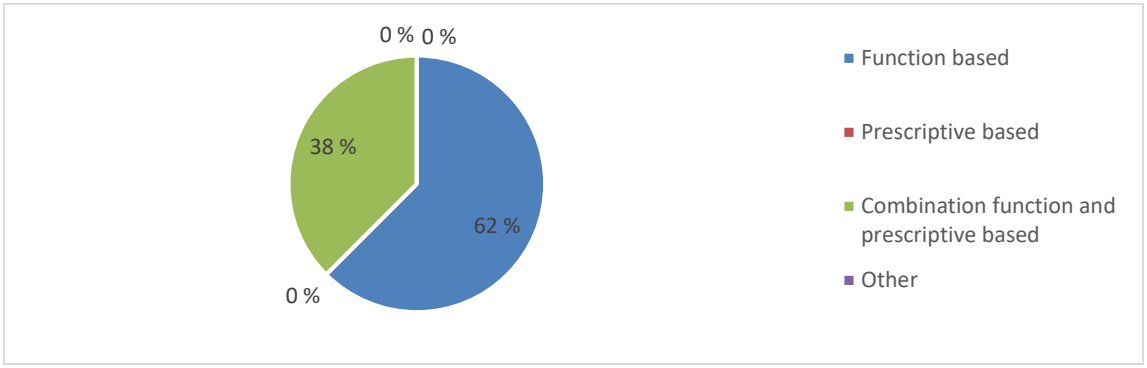

Figure 7-5 Which form of regulation is preferable? Percentage distribution of answers given in the survey and additional comments.

Table 7-1 If you answered "Both functional and prescriptive" to the question above, specify what should be functional based and what should be prescriptive?

Could certainly be a combination at some points, but I think it is not appropriate to start a new industry with new designs with prescriptive rules.
Prescriptive should be in relation to technical integrity, e.g. mooring systems, Metocean data used as a basis for the installations, Class vs NYTEK, etc.
Most of the requirements should be function-based to ensure technological neutrality and facilitate innovation. Prescriptive requirements should be used to establish minimum security level requirements.
Most of the requirements should be function-based, to ensure technological neutrality and facilitate innovation. There should be prescriptive that set minimum requirements for security levels.
The vast majority should be function-based, but not annual probability of loads and the like.
Function-based - HSE (partly), fish escape (risk-based approach), vessel operations, Function-based is largely preferable, but requires a high level of competence and integrity on the part of the operator and designer. Prescriptive - stability, structural safety, anchoring, HSE (partly)
It should be prescriptive where there are grounds for using prescriptive regulations. It can e.g. be technical analyses to document structural capacity. For many concepts, there will be standards that fit there.

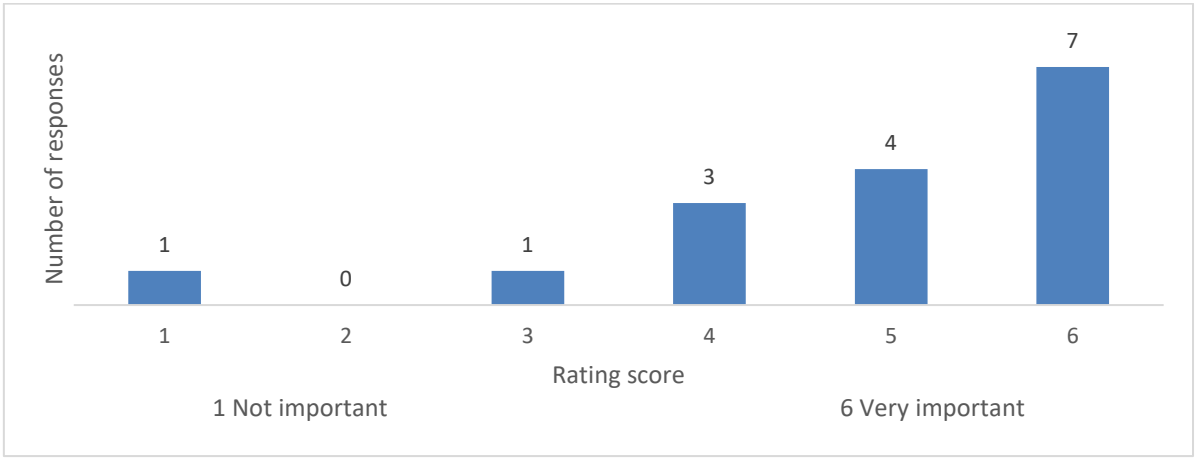

Figure 7-6 When using function-based regulations, to what extent is it important that the authorities develop guidelines that describe design principles and standards/codes that define the authorities' expectations for fulfilling functional requirements?

7.4 Responsibilities

As of today, the responsibility for approving that the technical quality of the installations is in accordance with the requirements is delegated to accredited certification companies.

The participants were asked about their view on who should have this responsibility for HTH.

Based on the response shown in Figure 7-7, it seems clear that the opinion of the responders is that operators should have the main responsibility for managing the risk in HTH. This is an approach which is similar to what is the case for the oil and gas industry in Norway, and this will make the breeders/operators responsible to a much larger extent than what is the case today and requires that the operators take a more active role in ensuring that all requirements are fulfilled.

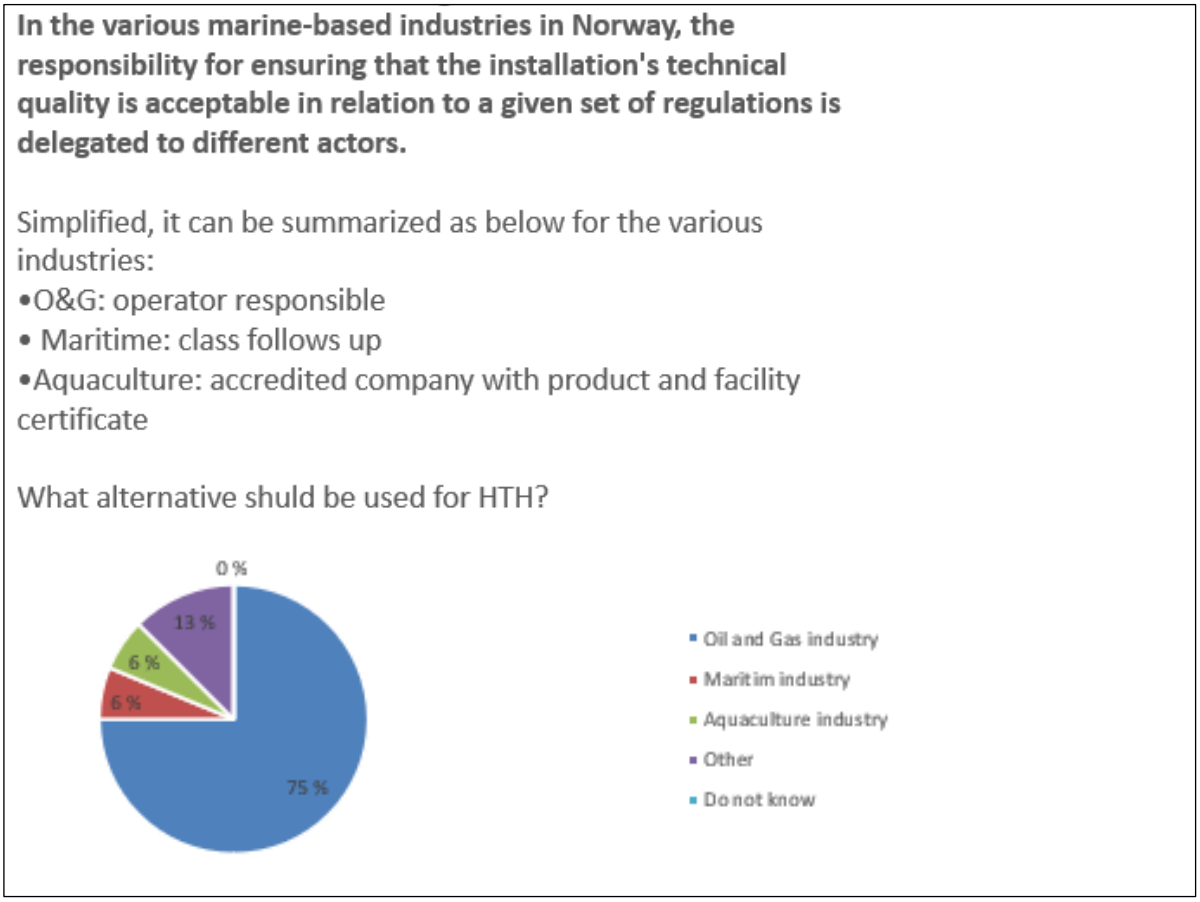

Figure 7-7 Responsibility to ensure technical quality of installation

Questions related to level of coordination of responsibilities between the different authorities were asked to the participants as seen in figures below.

From Figure 7-8, Figure 7-9 and Table 7-2 it is clear that the responders want a change from today's set-up where coordination between different authorities, as reported in the interviews, may be scarce and cumbersome, meaning that for HTH one coordinating authority should ensure that regulations, requirements to organisations and follow-up of projects are coordinated across the various disciplines to ensure an efficient and equal follow-up of the various projects.

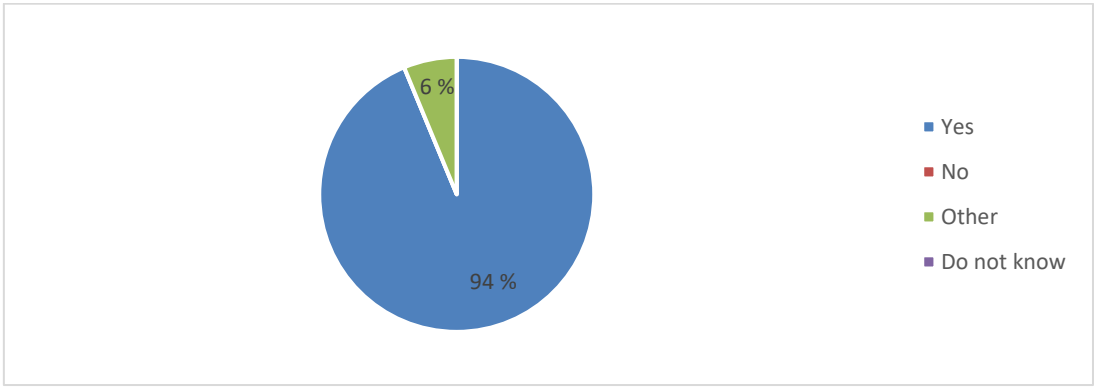

Figure 7-8 Should there be a coordinating authority that coordinates regulations, requirements for organizations and follow-up of projects for HTH? Percentage distribution of answers given in the survey.

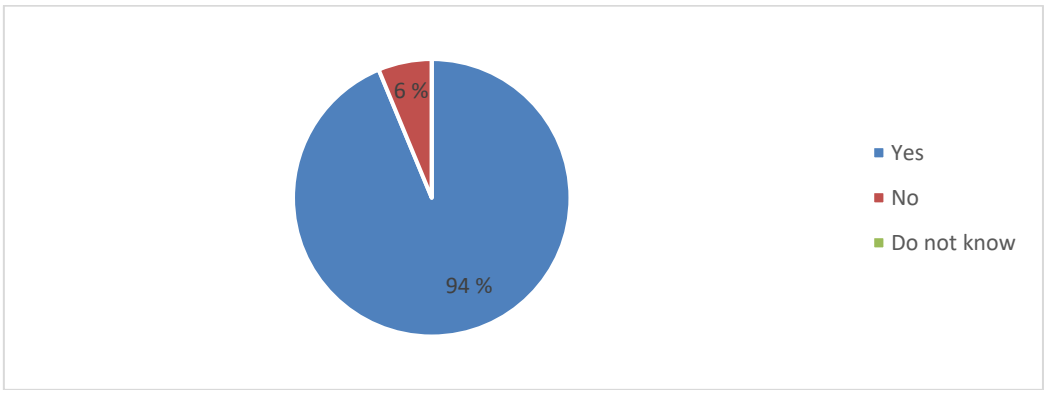

Figure 7-9 Should a coordinating authority coordinate all necessary "supervisory authorities" (HSE, technical, environmental, fish welfare, etc.)? Percentage distribution of answers given in the survey and additional comments.

Table 7-2 If one coordinating authority is not to coordinate all "supervisory authorities", what should be excluded?

Biology, fish welfare
Perhaps ask a little about the degree of coordination. And sets requirements for equal treatment from other authorities such as the Norwegian Food Safety Authority; that there will be no regional differences, but handled equally at national level.
Similar to maritime operations, e.g. class for technical requirements and SDir for HSE/SOLAS/security
Answered yes above, but if an authority is to coordinate everything it should have minimum competence in all areas and cooperation between the "authorities" must be clearly defined.

7.5 Risk management

Based on the large number of accidents and the response in interviews, risk management within the aquaculture industry seems to be deficient and we have therefore asked what requirements and expectations are needed in HTH.

Responses to the questions related to risk management are shown in Figure 7-10 and Table 7-3. It is quite clear that requirements and expectations from the authorities for risk management in HTH need to be more clearly defined compared to traditional aquaculture.

Some of the areas where this is especially relevant are risk for personnel, fish welfare and fish escape. There are also several responses stating that the risk management should be based on barrier management thinking and that a holistic risk management system is the basis.

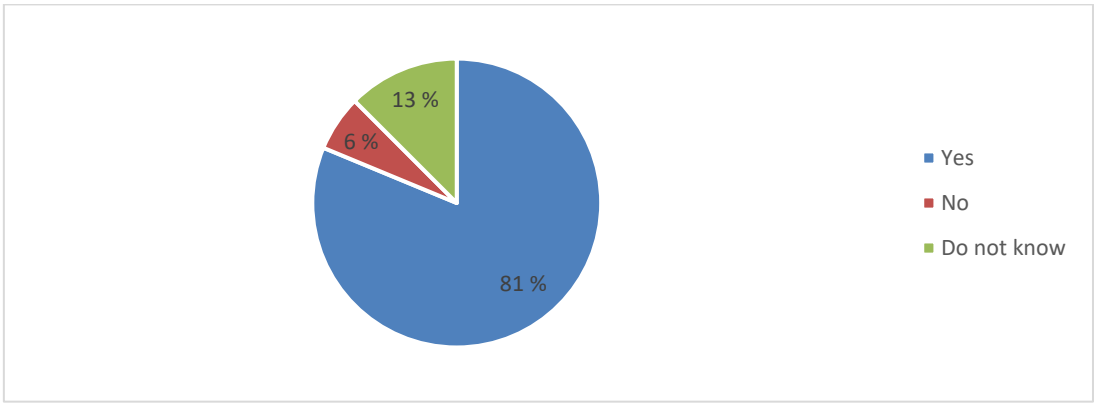

Figure 7-10 Is there a need for clearer requirements and expectations from the authorities for risk management in HTH compared to traditional aquaculture? Percentage distribution of answers given in the survey.

Table 7-3 Ref. question above. If you answered "Yes", which areas is this relevant for?

Big difference in technical risk and requirements for robustness by operating "offshore" compared to traditional farming. There will also be a range of technical solutions with an associated risk picture, which means that there must be clear guidelines for what is acceptable operation/design from a risk perspective.
Loss of equipment, escape, work accidents etc.
For all areas. There must be a requirement for holistic risk management where the businesses look at different areas in a context.
The challenge lies in the interfaces between e.g. The Norwegian Labour Inspection Authority and the Norwegian Maritime Directorate vs the Norwegian Directorate of Fisheries' overriding function. Not sure if this became any clearer with the revised NYTEK.
The most important thing for us is to start from the basic principles for: 1. risk-based barrier management, 2. functional requirements which are primarily aimed at the project's overall security system.
We are primarily concerned with the methodology in which the choice of technical standards and requirements should be included. Our assessment is that the regulatory starting points for technical safety should be based on three basic principles: i) risk-based barrier management through ii) functional requirements primarily aimed at iii) a project's comprehensive security system (including internal control).
Comprehensive risk management that includes people, fish welfare, material values, fish escape and the environment.
Comprehensive risk management that covers people, fish welfare, escapes, external environment and material assets.
personal safety and working environment vessel operation fish welfare escape and lifetime analyses Technology qualification competence of the actors
Clear intentions and requirements for risk analyses. Today, this is handled on a case-by-case basis
Most items

8 REFERENCES

/1/	https://www.fiskeridir.no/Akvakultur/Dokumenter/Rapporter/Gjennomgang-av-regelverk-knyttet-til-havbruksinstallasjoner-offshore
/2/	https://www.regjeringen.no/no/dokumenter/havbruk-til-havs/id2625352/
/3/	ISO/IEC Guide 51:2014 (E), Safety aspects, guideline for their inclusion in standards
/4/	Tilsynsstrategi og HMS-regelverk i norsk petroleumsvirksomhetIArbeidsdepartementet 27.8.2013 https://www.regjeringen.no/globalassets/upload/ad/temadokumenter/arbeidsmiljo_og_sikkerhet/utvalgsrapport_hms-regelverk_endelig_2008_2013.pdf
/5/	FOR-2011-08-16-849; Forskrift om krav til teknisk standard for flytende akvakulturanlegg (NYTEK-forskriften)
/6/	NS9415:2009; Flytende oppdrettsanlegg – Krav til lokalitetsundersøkelse, risikoanalyse, utforming, dimensjonering, utførelse, montering og drift, rev1 (2009-11-10)
/7/	NS9415:2021; Flytende akvakulturanlegg — Lokalitetsundersøkelse, prosjektering, utførelse og bruk, rev 1.0; 2021-08-09
/8/	FOR-2002-08-22-1484; Forskrift om krav til teknisk standard for akvakulturanlegg for fisk i sjø, innsjø og vassdrag (NYTEK23), https://lovdata.no/dokument/SF/forskrift/2022-08-22-1484?q=NYTEK
/9/	FOR-2010-04-29-634; Forskrift om utforming og utrustning av innretninger med mer i petroleumsvirksomheten (innretningsforskriften)
/10/	FOR-2010-02-12-158; Forskrift om helse, miljø og sikkerhet i petroleumsvirksomheten og på enkelte landanlegg (rammeforskriften)
/11/	FOR-2010-04-29-611; Forskrift om styring og opplysningsplikt i petroleumsvirksomheten og på enkelte landanlegg (styringsforskriften)
/12/	FOR-2010-04-29-613; Forskrift om utføring av aktiviteter i petroleumsvirksomheten (aktivitetsforskriften)
/13/	Veiledning til Innretningsforskriften; 26.04.2019, https://www.ptil.no/contentassets/f18375b7184d4cd68fc1c733b318b3dc/innretningsforskriften_veiledning_n.pdf
/14/	https://www.ptil.no/en/supervision/acknowledgements-of-compliance/acknowledgements-of-compliance-aoc/
/15/	Handbook for Acknowledgement of compliance (AoC) rev 05, august 2015, Rederiforbundet https://rederi.no/globalassets/dokumenter/alle/fagomrader/smi/aoc-handbook---revision-05.pdf
/16/	DNVGL-OS-E301 Position mooring - Rules and standards, Jul 2021
/17/	https://www.sdir.no/sjofart/fartoy/fartoystyper/flyttbare-innretninger/