# Design of, and learning from simulator-based contingency training in aquaculture

Caroline Kristensen

*SINTEF Digital, Norway. E-mail: caroline.kristensen@sintef.no*

Siri Mariane Holen

*SINTEF Digital, Norway. E-mail: siri.holen@sintef.no*

Gunnar Lamvik

*SINTEF Digital, Norway. E-mail: gunnar.lamvik@sintef.no*

Eivind H. Okstad

*SINTEF Digital, Norway. E-mail: eivind.h.okstad@sintef.no*

Ranveig Kviseth Tinmannsvik

*SINTEF Digital, Norway. E-mail: ranveig.k.tinmannsvik@sintef.no*

Contingency training in sea-based aquaculture becomes an increasingly important part of the emergency preparedness. Like other industries, this is especially related to new technologies being introduced to support critical emergency preparedness functions, as well as communication technology and new ways of interaction between involved parties in crisis situations. Simulators adapted to the relevant physical environments are useful approaches for contingency training as part of the emergency preparedness. Such means makes it possible to practice for activities and decisions in realistic emergency preparedness situations that are difficult to carry out in a real physical environment. There exist simulator centres in Norway adapted for training in both normal operations and emergency situations. These centres are mostly aimed at the maritime industry but have not so far covered the specific needs seen in the aquaculture industry when it comes to emergency preparedness. This paper documents the process and knowledge gained by taking part in the planning work with industrial partners leading up to a contingency exercise, observing its execution-, and the evaluation afterwards. By carrying out this pilot of a simulator-based contingency exercise, the industry partners in collaboration with research partners will achieve a basis for further testing, evaluation, and development of contingency training fitted for the needs in the aquaculture industry.

*Keywords*: simulator training, emergency preparedness, sea-based aquaculture, contingency

## 1. Introduction

The Norwegian aquaculture and fish farming industry is exposed to safety risks daily, as for example mass death or escape of fish, fire, or staff getting injured. There is an inherent safety risk in carrying out fish farming operations, with threats to both humans and fish, as well as environment and economical values. Contingency training in sea-based aquaculture therefore becomes an increasingly important part of the emergency preparedness. Like for other industries, new technologies are being introduced to support critical emergency preparedness functions, such as the use of simulators in contingency training.

The MarinSim project developed a simulator-based platform for training on operational-risk situations in sea-based aquaculture, but it did not cover emergency preparedness (Holmen et al. 2017). Therefore, one objective of an ongoing research project (see section 3.1.3) is to develop a simulator-based training concept adapted to the needs of emergency preparedness in sea-based aquaculture (Holen et al. 2020). This paper documents the process and knowledge gained from planning, observing, and evaluating a simulation exercise in sea-based fish farming. The objective is to achieve a basis for further testing, evaluation, and development of contingency training fitted for the needs in the aquaculture industry.

### 1.1. *Background*

Simulator training is an active teaching method founded on the problem-based-learning (PBL) model. It has been adopted in an increasing amount of education disciplines in different industries (Colombo and Golzio 2016). Emergency preparedness training is often a combination of both classroom-training and simulator training (Uhlig et al. 2016). Classroom training conveys the theoretical knowledge and walk-throughs of the procedures, and the simulator-based training is where the team is put in a simulated reality (Uhlig et al. 2016). Use of simulator-based contingency training have become a more common tool in emergency preparedness throughout different industries such as aviation, rail, maritime, healthcare, mining and construction. Simulators for training industrial operators are often known as Operator Training Simulators (OTSs), and they mainly concern on-site training (Marcano et al. 2019). Research indicates that simulators are valuable and useful tools for enabling the operators to create good understanding and knowledge about safety and security (Marcano et al. 2019; Bergamo et al. 2022; Raza et al. 2019). Holmen et al. (2017) highlights sea-based aquaculture as an industry with a potential for applying simulator in contingency training.

Proceedings of the 32nd European Safety and Reliability Conference
*Edited by* Maria Chiara Leva, Edoardo Patelli, Luca Podofillini, and Simon Wilson

ISBN: 981-973-0000-00-0 :: doi: 10.3850/981-973-0000-00-0_esrel2022-paper

### 1.2. *Literature*

When planning a contingency training concept, it is important to define the main goal of the training. By defining the goal, it is easier to identify the different needs that must be covered to achieve that goal.

The goal for a simulator-based contingency exercise is, according to the PBL perspective, for the participants to face unstructured problems that reflects a complex work situation where one identifies and prevent different risks. Onifade (2021) argues that effective training can be ensured through the training design. If the training design is developed in a systematic process that covers all the necessary knowledge crucial for the participants, and the participants have basic knowledge about their everyday working conditions, they are better equipped to train on handling complex and abnormal situations in the simulator. Phrased differently “If employees play a part in identifying their own training needs this can improve the targeting of training and also increase the motivation of trainees” (Simpson and Tang 2011). Although, this is often not the case, since just a minor share of the respondents in the above study “stated that they played some role in the identification of their own training needs.” We can refer to this description as a so-called user centric approach, an explanation that emphasises the end-users' own norms and values. The idea is that when emphasising a training design based on the end-users' own ideals and taken for granted values - when they themselves find it relevant and useful for their everyday life on board - the training will be more beneficial and useful for the seafarers themselves (see for example Kim et al. 2021).

Development of industry-specific contingency training is a complex process, and scenario-based simulation is one way to achieve a reliable and effective training program (Raza et al. 2019). Using scenarios based on real-life situations makes it possible to set up for training situational awareness and decision-making based on available technical and operational information and knowledge within the given participants (Holmen et al. 2017). Scenarios can be designed based on previous incidents as well as possible future incidents. By reproducing a real incident, the participants can learn what could have been done differently, what was done right, and ways to prevent an accident to evolve (Holmen et al. 2017).

Scenario-based simulator training is most often conducted as team-based training, as operators in real-life situations almost always work in teams. Knowing how to communicate with each other, and with external actors, is therefore crucial in an emergency setting (Wahl and Kongsvik 2018). Communication skills and collaboration can be exercised in simulator-based training. Communication skills include the importance of leaders who listen, ask questions, and respond to concerns from their team. Communication is also important in the evaluation phase of simulation exercises. Here, the participants, their leaders and the external actors can all discuss the simulation to gain a common understanding of the scenario, the decisions made, different roles and responsibilities, and define learning aspects (Wahl and Kongsvik 2018).

Analysing communication in real time can potentially provide valuable insights into the readiness of the crew, risk perception, individual- and team confidence level (Naqvi et al. 2018).

Team-based simulation training is unfortunately challenging because training is requiring substantial coordination, time and costs, and is therefore often limited to only once or twice a year (Marcano et al. 2019).

## 2. Methodology

The methodological approach used in this project is qualitative and covers the range from workshops, personal interviews and observations at the simulator, discussions, and evaluations after the exercise. The contingency exercise took place at a safety training centre in March 2022. Figure 1 indicates the methodology or work process applied in this study.

A literature study of previous research concerning use of technology in emergency preparedness and contingency exercises was conducted beforehand (see section 1.2), and a status of simulator-based training seen from various industries has been established.

The contingency exercise was developed and organized by the safety training centre, where the simulator is located, and the exercise was implemented. The process took place in close collaboration with the shipping company responsible for the whole research project and thus, also the contingency exercise.

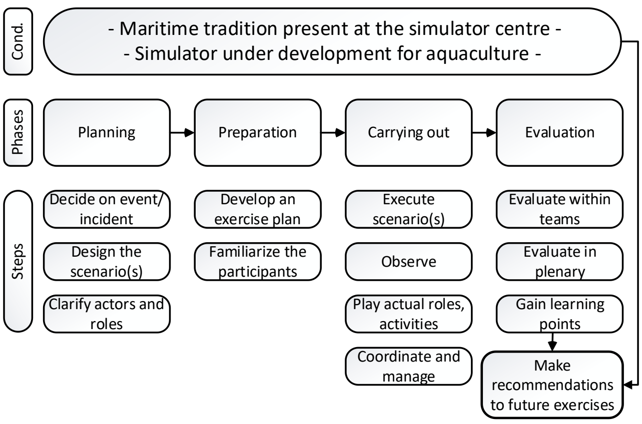


Figure 1. Work process applied to this study

## 3. Results

The results from this study are presented as descriptions of the phases or steps in the methodology shown in Figure 1.

### 3.1. *Planning the exercise*

This section describes steps and important issues, as well as involvement from researchers in the planning phase of the exercise.

#### 3.1.1. *Early planning*

The contingency exercise was planned by the partners in the research project, namely a shipping company (responsible partner, hereafter titled company), the safety training centre and researchers. The planning was mainly done in online meetings between these partners and started by a first meeting in autumn 2021.

Originally the exercise was to be held over two days in March 2022. Exercises carried out on the simulator normally takes two days according to experiences at the safety training centre. Training related to maritime activity is required from the Norwegian Maritime Directorate.

During the second meeting held in December 2021, the company suggested the exercise scenario should define which vessels to involve. A scenario concerning escape and mass death of fish was selected (see section 3.1.3). This scenario involves most of the critical actors and emergency preparedness functions seen in the aquaculture industry. The safety training centre also pointed out that the exercise should include as many needs as possible, and at the same time, not being too complex. The solution was to adapt a comprehensive scenario with regards to practice and coordinate as many emergency preparedness functions as possible at the same time.

There was from early on a desire to involve fish farmers in the scenario, as they are an important operational actor in any aquaculture operation. In addition, relevant authorities such as the Norwegian Directorate of Fisheries and the Norwegian Food Safety Authority are central authority actors. This aspect was considered in the further planning of the exercise.

During the third planning meeting in January 2022 a more detailed description of the scenario was presented. This scenario was selected from different emergency preparedness scenarios identified earlier in the project (Holen et al. 2021). The scenario was adapted so that it could be played out in the simulator. A document was prepared by the company and the safety training centre describing essential information about the upcoming exercise. Examples of information were number of - and types of vessels to be involved, their locations when start-up of scenario, and which crew to be trained. In addition, a short version of the scenario was outlined as to be delivered to the participants prior to the exercise. A debrief scheme was included that was supposed to be filled out by each crew or team after the exercise.

The researchers' role in the exercise was decided to be present and observing the exercise and the debrief afterwards. The role of an independent representative for evaluation was also mentioned, but not prioritised. According to the safety training centre, this role is typically provided by a representative with knowledge of the organisation, or the units being trained.

The project group was also informed about a specific software tool (to be used on computer) and a related crises management app (to be used on mobile phone) that the company planned to test during the exercise. The app provided functionality for notification and communication during an event (phone/ message), mobilization of resources, activity management and status (log) directed towards teams, as well as logging photos and videos of events connected to activities.

The fourth and the last meeting prior to the exercise was held in mid-February 2022. It was part of a physical workshop for the entire research project and the venue was at the safety training centre (the simulator). The latest version of the exercise description was presented, and both the project members and industry partners were able to comment on topics in the plan. The management of the exercise was explained, including what roles that should be played by others (internally facilitated) to get the complete scenario. It was also informed that the exercise would be carried out in one day, and not two days as indicated earlier. This includes familiarisation and debrief/evaluation. The training scenario would last for two hours.

#### 3.1.2. *Who the training was intended for*

Seen from the company's point of view, the main aim of the exercise was to train the appointed emergency group of the company. Next, it was to apply practical knowledge and improve non-technical skills of the involved crew to work as a team on a ship-bridge during a major incident, with regards to the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, the International Ship and Port Facility Security (ISPS) regulations and regulations from the Norwegian Food Safety Authority. As a contingency exercise, all relevant actors responsible during major incidents or accidents sought to be involved. The goal was to enable the participants to practice communication in a stressful environment, making fast and effective decisions, and handle the consequences of their decisions. The exercise sought to challenge the participants in areas of responsibility and regulations they normally do not practice on a daily basis.

#### 3.1.3. *Choosing the scenario*

As part of the ongoing research project Coastal emergency preparedness (In Norwegian: Kystnær beredskap), one of the work packages prepared a GAP-analysis to identify different scenarios, relevant to the risks threatening sea-based aquaculture. The scenarios were based on defined hazard and accident conditions, identified through interviews with relevant actors, observations, statistics, and earlier research (Holen et al. 2021). When developing the simulator-based contingency training exercise at the safety training centre, one scenario from this GAP-analysis was chosen.

The chosen scenario concerned "mass death of fish during a de-lousing operation, where an escape of fish occurred". The actual scenario was chosen because it concerns safety risks with the potential of great damage and loss of fish and potentially dangerous situations for humans. The scenario also requires the involvement of several agencies and organisations in the industry and several emergency preparedness functions from various actors, such as live fish carriers, fish farm service boats, high speed diving boats, coastal radio, and fishermen in the area.

The vessels were given a planned route to follow during the exercise. The participants were to keep to the route and handle situations that could occur. The scenario describes a situation where the live fish carrier “Vikna” is de-lousing CMS-sick fish (Cardiomyopathy Syndrome) at the location in Mid-Norway. The disease was not known before the de-lousing started.

A total of 100 000 fish has died due to the de-lousing. At the same time, a tear in the net in the cage is detected, and it is assumed that the tear caused over 10 000 fish to escape from the net cage. Recapture must be initiated immediately. The goal of the exercise was to see how the participants would react in this situation, and how they would handle unwanted events.

### 3.2. *Preparation*

The exercise was developed to be a scenario-based simulation exercise to make it as realistic as possible. To give the participants a starting point, some information about the exercise was given beforehand. The information consisted of a general description of the exercise, leaving out information about the specific scenario and other elements and skills they were supposed to be challenged on.

The safety training centre had, prior to the exercise, programmed extra elements and incidents that could happen during the exercise in addition to the general scenario. The instructors were to monitor the participants' behaviour and actions throughout the exercise and start different incidents when the participants felt calmer and could be challenged more.

In total, 19 participants, divided over 11 roles, would be contributing to the exercise, see Table 1. The roles were the different groups of actors represented in the exercise, such as the vessels, the appointed emergency group and external actors. Some participants would function in several roles, as for example a representative from the shipping company was playing both the role as the Norwegian Directorate of Fisheries and the Norwegian Food Safety Authorities. Some roles would also be played out by a representative from the safety training centre, as for example the crew on the high-speed diving boat and the coastal radio. The role of the media was to be played out by representatives from a communication firm hired by the safety training centre for the exercise and was to act as the press interfering with the bridge crews and the appointed emergency group. Other roles such as the crews on the vessels and the appointed emergency group were to be played out by 11 real participants. Out of the 19 participants, 11 would participate at the simulator premises, while 8 would participate remote from elsewhere. The vessel crews were all to sit in their own simulated vessel-bridge, and the only way to communicate between the vessels was by telephone (app) as it would be in real life, or through VHF Channel 16.

Table 1: Participating actors in the exercise

| Role | Number of roles | Number of participants |
|---|---|---|
| Live fish carriers | 2 | 3 |
| Fish farm service boats | 2 | 4 |
| High speed diving boat | 1 | 1 |
| Appointed emergency group | 1 | 4 |
| Coastal radio | 1 | 1 |
| Media | 1 | 4 |
| Fish farm owner | 1 | 1 |
| Authorities | 2 | 1 |
| **Sum:** | **11** | **19** |

### 3.3. *Carrying out the exercise*

As already mentioned, the scenario was finally set to last for two hours. Before the exercise started, all the participants were familiarized with the simulator, and its equipment and controllers on the bridge and with the crane simulator. Earlier in the day of the exercise, the crew on the small high speed diver boat cancelled and was not going to attend the exercise. The exercise now consisted of four vessels with two crew members aboard each vessel and four members of the emergency group, in addition to the external participants played by the organizers from the safety training centre and the company.

Figure 2. Example views from the simulator

When starting the exercise, all vessel crews got a task to start with. The bridge on the main live fish carrier, Vikna was told to start loading fish onto the vessel. After loading approximately 200 tons of fish, the crew were given the information that the fish had started dying, and the crew now had to react to this situation. It was observed that the Vikna crew acted fast and calm in their decision-making process when they decided to stop loading fish and headed against shore for emergency slaughter. The captain quickly informed both the emergency group and the fish farmer about the situation. The appointed emergency group then informed both the Norwegian Food Safety Authority and Norwegian Fish Directorate. The captain updated the app with their completed tasks. The captain’s mate then started manoeuvring Vikna towards destination at shore.

Right after Vikna had left, the Borgan service boat got a message about a tear in the net, and that fish had started to escape. The crew now had to handle this situation quickly, before too many fish had escaped.

On their way back after unloading the dead fish, the crew on Vikna got the message about a missing person on board Vikna, and a suspected man overboard situation. The crew quickly got in contact with the other vessels in the area, informing them about the situation and implemented a search and rescue operation. They also contacted the appointed emergency group who then monitored the situation. All vessels were informed and communicated through the app regularly during the incident, making it easier for everyone involved to keep track of the situation. The crew had to deal with phone calls from stressed relatives and third parties that had heard about, or seen the situation, and wondered if it was their loved one who was missing. The captain's mate handled the phone calls calmly and did not give out any sensitive information. After a while, another vessel informed Vikna that they had found a person in the water and that the situation did not look good. Vikna then got in contact with the lifeboat and rescue helicopter.

The crew started discussing, whether, or not they should have called "mayday" right away. In general, the handling of the man overboard incident was characterized by a calm and controlled activity on board the different vessels. The seafarers are drilled and has trained on this type of accidents several times over the years, so they knew how to act on this unforeseen event. The man overboard event turned out quite different than the essence part of the exercise, since the overall aim this day was to surprise and challenge the seafarers attending the training activity.

The exercise ended abruptly due to time and the man overboard incident was not fully resolved as part of the scenario.

### 3.4. *Evaluating the exercise*

Immediately after the exercise was finished, all participants on the different vessels were handed the evaluation sheet, filled with questions concerning thoughts about their own performance in the exercise, and how it went. Only the bridge crews got this evaluation sheet, not the appointed emergency group. After evaluating their own performance, a joint evaluation was carried out. The vessel crews were able to share their experiences with the other vessel crews, the appointed emergency group and the instructors. Most of the vessel crews were pleased with the exercise in general, and felt that they had handled the scenario, the unexpected events and the communication on the bridge, between the vessels and the external actors. At the same time, some of the vessel crews explained that it was sometimes hard to reach the appointed emergency group and get the right information quickly. The appointed emergency group and some of the vessel crews actually described the exercise as slightly chaotic but acknowledged that they gained full control in the end.

All participants found the app to be a useful resource, but they also highlighted some challenges when using the app during the exercise. The vessel crews agreed that they had gotten little, to no training on how to use the app beforehand, and some participants therefore found it hard to use during the exercise. Some also pointed out that the app sometimes provided too much information that did not concern their team. It was, therefore, difficult to follow all the information given throughout the exercise.

The appointed emergency group pointed out that too many incidents happened at once, and that it was difficult to get full perspective of the situation. Once they had gotten full overview over the situation and distributed people to different tasks and incidents, the information flow went a lot smoother, and everyone seemed to know their responsibility better.

Two weeks after the exercise, the researchers met with a representative from the safety training centre and the shipping company, respectively, to hear their thoughts about the exercise. The representative from the safety training centre described the exercise as challenging, but successful. Such a complex exercise implied a whole new concept for the simulator, as the first of its kind. Even though the simulator had some limitations when it came to visible details as for example the tear in the cage, he emphasised that the important aspect of the exercise was not how they operated the vessels, but rather the communication between the bridge crews and the appointed emergency group. It was the choices and decisions they made during the exercise that presented the important learning aspects. As mentioned, the exercise was described as sometimes chaotic, and that too many incidents happened at ones. In addition, the media pressure was high throughout the exercise, with several roles played from remote. The instructors acknowledged that when they inserted the man overboard incident, they didn't notice how stressed the appointed emergency group was, as they only saw the situation from the vessels.

Even though the evaluation showed that both the participants and instructors realised that it was a bit too many new training aspects in the exercise, they now recognised where the limitations are, and what they need to practice more. This knowledge will become valuable input in planning future simulator training sessions.

## 4. Discussion

In the following sections, a discussion structured according to different perspectives of the exercise is presented with regards to how future exercises in sea-based fish farming could be designed. Topics related to organisational aspects (roles and responsibilities), information and communication means, and the technology provided at the simulator and for communication purposes, are discussed.

### 4.1. *Roles and responsibility*

The first aspect to discuss concerns the actors' roles and responsibility in the exercise. For this exercise, one emergency preparedness organization was to be trained using simulation, but as observed, this organization was both the one being trained, and took responsibility in acting out some of the external roles in the exercise. Only three roles of the whole exercise were played by others than employees in the company's organization. This raises the question of reliability of the exercise and also questions if the exercise used its full potential for learning and relevant input to the organization. Also, one of the members of the emergency group, had played a central part in planning the exercise, and thereby knew about the scenario beforehand. The point of scenario-based contingency training is to train the participants on handling unexpected events in a familiar context. If somebody already knew about the scenario, it will naturally be an issue to consider possible effects on how participants acted.

Also, by not including external entities, such as for example The Norwegian Directorate of Fisheries and The Norwegian Food Safety Authority, valuable learning points both for the participants not interacting with "real" actors, and the real actors not being included, may be lost. With that said, this specific exercise was meant to train the appointed emergency group, and as in real life, they were not sitting together in an office awaiting a crisis. For the emergency group, observations showed little control and sharing of responsibility early in the exercise. It took some time for them to coordinate with each other, and they achieved full control gradually. They got to test their abilities concerning emergency preparedness, i.e., coordinating and handling unexpected and unwanted events.

In addition, due to some large and long lasting financial and industrial processes involving major actors in this sector, during the period the exercise were organized and completed, it was considered extra challenging to include several external companies and organizations into this training session. It was assessed, by the responsible company, better to have many roles “in house”, rather than not being able to complete an exercise at all.

### 4.2. *Information and communication*

The second aspect to discuss is information and communication. Information plays an important part in emergency preparedness, and therefore also in contingency training. Giving and receiving the correct information at appropriate amount, and to and from the right people are all important aspects of information in emergency preparedness. It is therefore crucial to include communication as a core element in emergency preparedness. For this exercise, communication played a central role in the unfolding of the events. The participants did practice several levels of communication during the exercise. It was communication between crew members on the same bridge and between different vessels, and communication with appointed emergency group and external actors.

The provided crises management app that was tested, established a new platform where every participant could follow the entire information flow during the exercise. This led the participants to feel updated on information and they have had enough information to execute further actions concerning the scenario that unfolded. As observed in the exercise, the crew members on Vikna could easily check the app to see who the appointed emergency group had contacted so they did not have to contact them themselves. The emergency group could check which vessels had executed which tasks, and thereby follow the incidents even when they themselves were not at the location.

As highlighted in the evaluation, some of the participants found the app providing too much information that did not apply to everyone. One concern about this was that valuable information could get lost or be overlooked, causing participants to not be able to handle incidents in the best possible way. In this exercise, the participants did not only use the app, as they also used telecommunication with the other actors. Here, short and accurate information was given to actors that were directly concerned. If some messages were not understood, the participants didn't hesitate to ask again, but if they noticed a message on the app they didn't actually recognize, they just overlooked it.

Even though the exercise was both stressful and chaotic at times, it was declared quite successful. Deficiencies, flaws and areas that needed more training was revealed, and thereby relevant points to include in future training exercises to better fit their needs.

### 4.3. *Technology*

The exercise concerned mainly training of the appointed emergency group´s ability to handle a crisis in sea-based aquaculture. Although no members of the appointed emergency group were present in the simulator during the exercise, one member out of four was at the actual simulator premises, located in an adjacent room.

Simulator-based exercises are supposed to match real-life situations to make the exercise as realistic as possible for the participants. In a real-life emergency situation in sea-based aquaculture, the appointed emergency group would not necessarily be sitting in the same location. As they never know when an emergency might occur, they might be in different places, and it was therefore a realistic approach to not include them at the simulator for the exercise. By using the simulator for the bridge crews, they got the feeling of their respective usual work situation and could react to the unforeseen incidents at the location. This made their communication with the appointed emergency group located in other places realistic. Another core aspect of technology used in the observed exercise, as mentioned earlier, was the use of the crisis management tool (app). Both the bridge crews and the appointed emergency group used the tool throughout the exercise. The tool provided a platform for communication, but also logging the incidents and actions made throughout the exercise. At the same time, relying fully on the tool could cause problems for the participants.

If some of the participants lost contact with the mobile application of the tool, forgot to update the app, or updated the wrong information, unwanted responding could occur, and the incidents could be handled wrong, which then could lead to possible dangerous situations. This problem could have been avoided if the participants had received an adequate amount of training in using the tool beforehand.

It was acknowledged in the evaluation and interview later on that they did not get enough training of the tool to exploit its full potential during the exercise, and it therefore became a bit stressful experience. The provided app seems to have great potential to enhance and provide even stronger influence on future exercises, both with thorough training in advance and with an improved and tailer made design of the actual training session.

## 5. Conclusion

The planning, preparation, execution, and evaluation of a training concept and exercise has been described. After observing the exercise, some valuable learning points have been identified.

Firstly, what came across as an obvious barrier in the exercise, was the effect of little, to no training of the technology beforehand. The confusion and miscommunication caused by the technology used in the exercise was not due to the technology itself, but rather that the participants were unfamiliar with using it. By getting a sufficient amount of familiarizing beforehand, using the equipment during the exercise would have been easier for the participants, they would have gotten a better experience from it and would have been able to concentrate more on the actual exercise and on handling the scenario and incidents happening.

Secondly, by using both familiar and new types of incidents as part of the scenario showed that the participants got a feeling of achievement while also being challenged. This did not only affect the participants, but it also gave valuable knowledge to the organizers and to the shipping company. By observing how the participants handled a familiar situation versus how they handled a new type of situation gives valuable learning on where the limits are, and what they need to practice more. It was easier to see where the limit of knowledge, experience and capacity goes when multiple events needed to be handled. Some of the situations that were experienced as chaotic also reveal where more training is needed.

Lastly, as also the literature states, evaluation is important to be able to take learning from exercises. As observed, an evaluation was carried out as the first thing after completing the exercise. Reflecting, discussing, and sharing knowledge gained in the exercise, is valuable for the participants to understand why actions were made when, where and why they were made. Learning how others handle the same situation and how to communicate and interact during stressful situations is essential knowledge gained for real life incidents and when planning future exercises. How the exercise was organized, which actors were included, or not included, and how one acted out the roles are crucial information to take learning from and bring new knowledge into future contingency exercises.

**Acknowledgement**

The paper is based on empirical data from the research project *Coastal emergency preparedness*, exploring increased safety in coastal waters through improved emergency preparedness. Financial support from The Research Council of Norway (innovation project 309305), strategic funds from SINTEF, as well as in-kind contributions from collaborating companies are gratefully acknowledged.

**References**

Bergamo, P., Streng, E., De Carvalho, M., Rosenkrantz, J., Ghorbani, Y. (2022). Simulation-based training and learning: A review on technology-enhanced education for the minerals industry. *Minerals Engineering 175, 107272.*

Colombo, S., Golzio, L. (2016). The Plant simulator as viable means to prevent and manage risk through competencies management: Experiment results. *Safety Science 84, 46-56.*

Holen, S.M., Okstad, E., Tinmannsvik, R.K., Holmen, I.M. (2021). Risk picture and GAP-analysis (In Norwegian: Risikobilde og GAP-analyse). SINTEF report 2020:01468 (restricted).

Holmen, I.M., Thorvaldsen, T., Aarsæther, K.G. (2017). Development of a simulator training platform for fish farm operations. Proceedings of the ASME 2017 *36th International Conference on Ocean, Offshore and Arctic Engineering OMAE*, June 25-30, 2017, Trondheim, Norway.

Kim, T.E., Sharma, A., Bustgaard, M., Gyldensten, W.C., Nymoen, O.K., Tusher, H.M., Nazir, S. (2021). The continuum of simulator-based maritime training and education. *WMU Journal of Maritime Affairs 20, 135-150.*

Marcano, L., Haugen, F., Sannerud, R., Komulainen, T.M.K. (2019). Review of simulator training practices for industrial operators: how can individual simulator training be enabled? *Safety Science 115, 414-424.*

Naqvi, S.A.M., Raza, M.A., Ybarra, V.T., Salehi, S., Teodoriu, C. (2018). Using content analysis through simulation-based training for offshore drilling operations: implications for process safety. *Process Safety and Environmental Protection 121, 290-298.*

Onifade, M. (2021). Towards an emergency preparedness for self-rescue from underground coal mines. *Process Safety and Environmental Protection 149, 946-957.*

Raza, M.A., Salehi, S., Ghazal, S., Ybarra, V.T., Naqvi, S.A.M., Cokely, E.T., Teodoriu, C. (2019). Situational awareness measurement in a simulation-based training framework for offshore well control operations. *J. Loss Prev. Process Ind. 62, 103921. International Conference of the IEEE Engineering in Medicine and Biology Society (pp. 4523-4529)*. IEEE.

Simpson, H., Tang, L. (2011). New shipboard technology and training provisions for seafarers. Cardiff, UK: Seafarers International Research Centre (SIRC), Cardiff University.

Uhlig, T., Roshani, F.C., Amodio, C., Rovera, A., Zekusic, N., Helmholz, H., Fairchild, M. (2016). ISS Emergency scenarios and a virtual training simulator for Flight Controllers. *Acta Astronautica 128, 513-520.*

Wahl, A.M., Kongsvik, T. (2018). Crew resource management training in the maritime industry; a literature review. *WMU Journal of Maritime Affairs 17, 377-396.*