

Call: EMFF-BlueEconomy-2018. Type of Action: EMFF-AG



Demonstration of intensive shellfish farming in **OPEN** waters with resilient and affordable **MODuLEs**

Grant Agreement nº 863562

Coordinator: Research & Development Concretes

D5.1. – Maritime and operational safety guide



With the contribution of the European Maritime and Fisheries Fund of the European Union

Deliverable Title	Maritime and operational safety guide
Deliverable No.	5.1
Related WP	5. Design optimization
Contractual date of Delivery	M9 (July 31 st , 2020)
Actual date of Delivery	M9 (July 31 st , 2020)
Deliverable Type	R (Report)
Dissemination level	PUBLIC
Lead beneficiary	RDC
Contributing participants	-
Author(s)	Cristina Maestre, Esteban Camacho
Checked and approved by	Esteban Camacho
Status	FINAL
Description in the GA	Guideline that describes the security measures for each step of the assembling, connections on open waters and operational activities. Measures to guarantee the maritime safety of in coastal and offshore waters. Updated in M15. Report, electronic format (PDF), approx. 90 pages. Language: English and Spanish

Version History

Version	Status	Date	Contribution (Partner)	Summary of changes
V0.1	Draft	24 th , July 2020	Cristina Maestre (RDC), Esteban Camacho (RDC)	Draft Version
V1.0	Final	31 st , July 2020	Esteban Camacho (RDC)	Final Version

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Executive summary

The Deliverable 5.1 is a public document that provides a global view of the different aspects that affect to safety and health in the use of the Formex® modules proposed in the OpenMode project. Aspects as maritime safety, occupational safety during the assembling and the farming, or the innovative connection procedures are covered.

The steps where safety is relevant have been introduced in temporal order, starting from the selection of a safe location for a floating module (climatological conditions and navigation are the main factors to be considered), and ending with the operations on it. The risk of the assembling procedures are detailed and quantified (from 0 to 3), describing after this what has to be considered for a safe floating of the structure. For the case of the modules that can be connected, a safe procedure and conditions to do this operation are described in section 5.

Section 6 describes the preventive and corrective safety measures to guarantee the maritime safety of a floating module. The first include the procedures to beacon the element, the video camera for control and the most common types of mooring systems. Among the corrective measures are the GPS and the load-cell in the mooring, both systems proposed by RDC in this project as innovations to report with an alert that a module is adrift.

Sections 7 (in English) and 8 (in Spanish) are a guide about the safety under service in the module. It describes the Personal Protection Equipment that may be required working on it and the novelties of the Formex® module compared with other marine aquaculture solutions. The risks working on the module are quantified (0 to 3), indicating their causes and preventive measures. The section includes the risks on the vessel as an element that may complement the work on a module. The section finishes with a gender analysis of the safety using a module.

Finally, the Annex I provides a description of the production cycle of molluscs on a floating farm, Annex II summarizes the legal procedures to propose the beaconing of a structure in Spain (where there are already two mussel farming polygons beaconed) and Annex III provides a short guide of knots to be used to reduce overexertion on the module.

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List of acronyms, abbreviations, and definitions

Table 1. List of acronyms, abbreviations, and definitions

Abbreviations	Meaning
®	Registered
AEMET	Agencia Española de Meteorología
APROMAR	Employers' Association of Aquaculture Producers – Spain
ASP	Amnesic shellfish poison
AtoN	Ayudas a la Navegación marítima - Calidad
BG	Blue Growth
BV	Baseline Value
CC.OO.	Workers Commissions (Spain)
CIAIM	Commission of the Investigation of Maritime Accidents and Incidents
COVID-19	Corona virus disease, year 2019
DSP	Diarrhetic shellfish poison
DXX	Deliverable number XX
EASME	Executive Agency for SMEs
EC	European Commission
EMFF	European Maritime and Fishery Fund
ES	Spain
EU	European Union
FRC	Fiber Reinforced Concrete
H2020	Horizon 2020
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IFC	International Finance Corporation
IMO	Maritime Consultive Organization
In	Indicator
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
KPI	Key Performance Indicator
MS	Milestone
MXX	Month XX
OC	Ordinary Concrete
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
PREFFOR	Prefabricados Formex SL
PSP	Paralytic shellfish poison
R&D	Research and Development
RDC	Research & Development Concretes SL
SME	Small and Medium enterprise
SO	Specific Objective

SOLAS	Safety of Life at Sea
UHPC	Ultra High-Performance Concrete
UHPFRC	Ultra High-Performance Fiber-Reinforced Concrete
WP	Work Package

1. Introduction

1.1. Scope of this document

This public deliverable (D5.1) is the first of the WP5, which started in M4 and covers all the Operation and user experiences that support the penetration of the solution in the market. The file will be updated in the last month of the Task 5.1 (M15).

The document identifies the risks and proposes safe procedures for all the steps of the module lifespan (assembling, floating, harvesting, connection on the sea...). Special attention is paid to the Occupational Health and Safety (OHS) working on the module and the beaconing of the structure, which differs from the long-line system typically used in most of the countries. The document quantifies the OHS risks of the different procedures and paying special attention to the navigation and beaconing.

This text has obtained information from several guides for OHS in aquaculture, adapting it for the modules that have been designed in the WP2 of the OpenMode project. Finally, the deliverable provides a simple guide in English and in Spanish that may be used for the farmers to show them the most relevant facts to do a safe work on the platform.

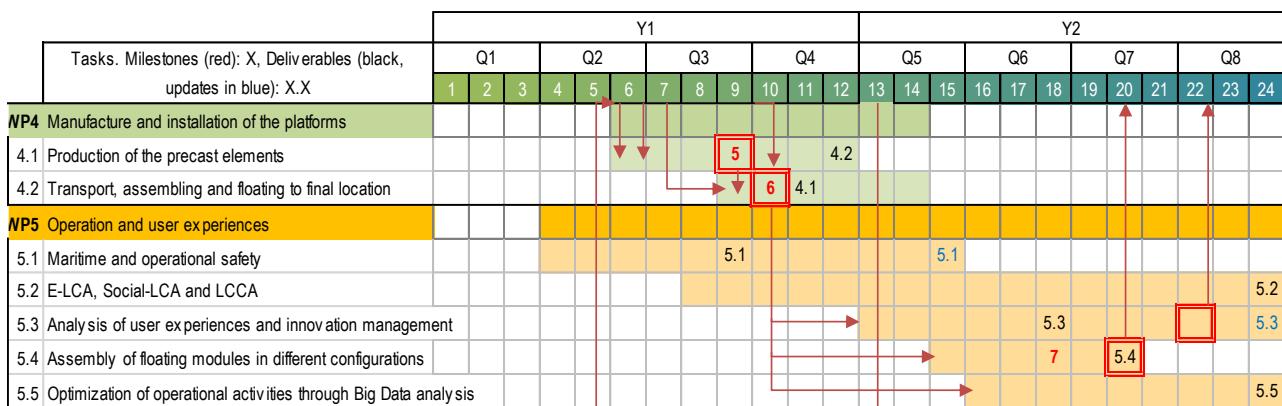


Figure 1. GANTT of the WP4 and WP5 of the project OpenMode

1.2. Audience

The intended audience for this public Deliverable is:

- The farmers and amateurs that may potentially use the module during the project and in the future, both if they purchase it or if part of the farming area will be assigned to them for its temporary use.
- The potential investors and clients, as stakeholders interested in understanding the harvesting procedure before a possible purchase.
- The European Commission, as funding institution of this project.
- The employees of the companies RDC and PREFFOR that are participating in the OpenMode project.

1.3. Structure of the document

The document is ordered treating in temporal order the safety of each step of the module lifespan: Selection of a safe location, safe assembling, safe floating, safe connection, and safe use under service conditions. The last is a brief guide for users and has been introduced first in English (section 7) and later in Spanish (section 8).

1.4. Preliminary remarks and relevant concepts

The company RDC and PREFFOR have cooperated for the development of this document. It is aligned with the Environmental, Health and Safety General Guidelines of the International Finance Corporation (IFC) of the World Bank Group [8].

In this text, the concept “open waters” implies the fact of being exposed to the waves with a significant fetch. In all the cases, the concept of navigation used is Coastal Navigation according the IALA Navguide [11], which is limited to areas within 50 nautical miles (nm) from the shore or the limit of the continental shelf (200 m in depth).

The documents included in the Annexes are not the core of the document but provide information that has been considered interesting for a better understanding of certain aspects.

The information provided in this document is indicative, not contractual. The employees, owners, assemblers and involved stakeholders are not exempt from conducting their own studies and reviews regarding the occupational health and safety of their installations (module, vessel...).

Finally, the section *Safety under service on the floating module* is translated also to Spanish, as it is considered a brief guide for the farmers that work on the module, and there are pilots of this project which will be installed in Spain.

1.5. Legal frame

The installation of marine aquaculture elements is regulated in most of the countries of the world. However, for mussel and oyster farming the most common element granted is the longline. The authorization given by the Administration of the different countries is generally for the exploitation of an area of water, where the farmer can use the system that he/she has described in the proposal. It is not common to find limitations to the length or surface of the device used to harvest in the authorized area, possibly because there are not yet floating structures in most of the countries in the world. In the project OpenMode several pilot modules with an area of 140 m² are going to be floated in Denmark (2 elements), Croatia (1 element) and Montenegro (1 element), where there is not experience with comparable structures for mollusc farming. The four authorizations requested in these countries were approved before July 2020. From the point of view of occupational health and safety, farming in this element is new in these locations, so there is no information in this field. The most adequate is that a company expert in risk prevention visits the structure once it is installed and indicates what measures and personal protection equipment are necessary.

The case of Spain is studied separately for having floating structures since the beginning of century XX. In 1961 the harvest of mussel exploitations in marine waters (named as “maritime area”) was

regulated. The largest farming region, Galicia, limited in 1986 the maximum area of a floating structure to 540 m² and the maximum length for the mussel ropes to 12 m. The objective of this regulation was to reduce the pressure on the marine environment.

Regarding occupational health and safety, Spain approved in 2006 the Framework Collective Agreement for the Marine Aquaculture, which embraced topics as the work organization, staff classification, types of working sessions, working hours and resting periods and occupational health and safety among other aspects. Since then, the labor relations in aquaculture have been regulated with framework agreements between the business organizations and the union representations. Currently in force, the V Collective Agreement for the marine national aquaculture was signed in 2019 by APROMAR (Employers' Association of Aquaculture Producers – Spain), the UGT (General Workers' Confederation, Maritime and Port Sector), the State Federations of services to citizens of the Workers Commissions (CC.OO.) representing the working community. This document excludes the self-employed and all the employees from the mussel farming sector.

2. Selection of a safe location for a module

Five are the main factors that have influence in the selection of the location of a module, of which two of them have a direct relation with safety. They are described as follows:

- **Legal availability** of the area to host mollusc farming installations. This factor depends on the Aquaculture plan of the region or country.
- **Biological suitability** of the location to grow a good quality product.
- **Depth:** The depths lower than 8 m reduce the potential farming capacity of the module. Depths higher than 35-40 m penalize the mooring costs and weights.
- **Climatological conditions:** This factor has an influence on safety. The farmers need to work on the module and intense swell or wind may unbalance him significantly. Significant currents may difficult the access from the vessel. In very cold waters (regions of Denmark, Norway...) the ice can also involve risks: The wet surface of the module may slip during some winter days. In the coldest regions, the ice of the water surface may damage the structure, so it needs to be designed submersible.
- **Risk for navigation:** A factor that reduces the risks for navigation is to choose a location that has a low density of marine traffic. This reduces the necessity to beacon the structure (which should be decided by the corresponding authority) and avoids potential future accidents. There are different online resources that indicate the density maps of marine traffic, as www.marinetraffic.com. The figure below shows the traffic density of some of the pilot modules that will be deployed in this project (yellow indicates medium density, red indicates high density).

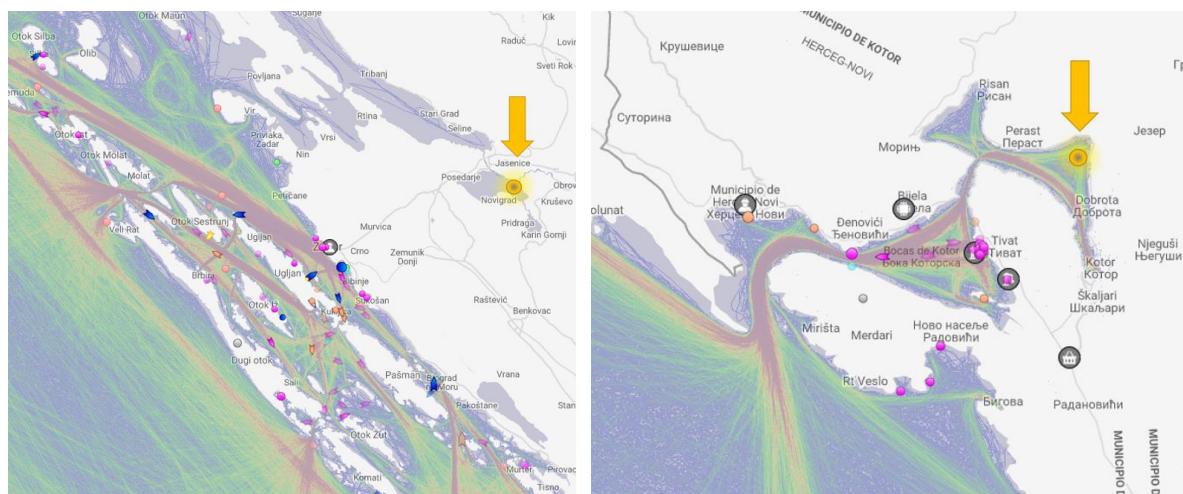


Figure 2. Density of marine traffic in the North of Croatia (left) and in the coast of Montenegro (right). The yellow spot indicates where the pilot module of this project will be located. Data obtained from the website www.marinetraffic.com

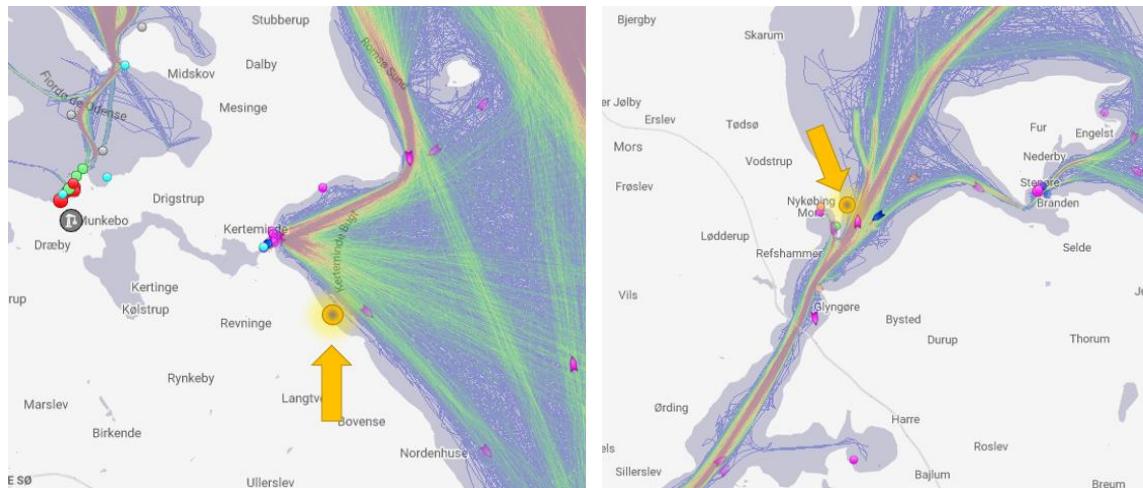


Figure 3. Density of marine traffic in the Danish area of Kerteminde (left) and in the Danish area of Nykøbing (right). The yellow spot indicates where the pilot module of this project will be located. Data obtained from the website www.marinetraffic.com

It should be mentioned that, despite the potential risk of having mollusc farming installations close to high density of marine traffic, this fact generates a recurrent swell (bow wave) that can boost the entrance of nutrients, which increases the growing rates and improves the productiveness (see figure 4).



Figure 4. Cruise ship entering in Valencia Port. The bow wave can be seen. It will arrive to the Formex® farm after 2-3 minutes, creating a turbulence that favours the growth of the harvest

3. Safety of the assembling procedures

The assembling procedure is the process to connect the precast elements to create a floating module. Generally, and depending on the region where the module is going to be installed, it requires an approved Project that includes a Safety and Health Study that covers the assembling steps.

The heaviest single elements are the floaters, with a weight of approx. 2 ton. The most significant factors that affect to the safety in the assembling procedure are:

- Assembling location: It can be in a flat flooring (port, deck...) or in the natural land of the coastline. The last may be only used if the floating procedure will be done using the tides.
- Working height: The sum of the diameter of the floaters and the depth of the beams will provide the maximum working height, which depending on the type of module may vary between 1,80 m and 3 m. Generally, a work is considered “at a height” when the distance from the feet of the worker to the flat surface exceeds the 2 meters.

The assembling can be carried out by any assembling team that is able to follow the assembling instructions provided by PREFFOR, including the safety procedures. Generally, an assembling team counts with 3 or 4 coordinated members. When the team is experienced in the field, they can assemble a 140 m² module in (6 to 8 hours, three employees), and a 540 m² Formex® raft in 2 days (16 hours, four employees). The works generally also require a crane driver and a rigger to support its works.

The following table shows the most frequent and significant risks that can be suffered in the assembling of a module.

Minimum surface to assemble the module: 24 x 24 m, completely clear to avoid tripping or falling and to facilitate the maneuver with the trucks, forklifts, and cranes.

The operators need to use the working clothes, helmet, leather gloves, security boots, rain clothes (if necessary), type C safety harness (if necessary), protection glasses and reflective vest.

The left column is in different color depending on its risk. The risk is considered the severity of the damage multiplied per the probability of occurrence. The risk can be identified in the colors indicated below:

Table 2. Level of risks considered in the analysis

0	1	2	3
Action not required	Not required to improve the preventive action	Take actions to reduce the risk	Work should not start until reducing the risk

Table 3. Risks identified for the assembling procedures

Risks of assembling the module		
Significant risks during assembling	Causes	Preventive measures
Cranes, trucks, forklifts, lifting platform		
Falling of elements lifted with the crane or forklift	Inadequate handling with the slings and/or incorrect movements with the machines	Follow the regulations regarding the use of the crane and the forklift. Use of slings and cranes according to the loads manipulated (they should have a plate that indicates the maximum load) and always using the safety lock. Inspection of the slings and hooks. Manipulation of the load without abruptness. Avoid the pass of personal under the load manipulated. If any anomaly in the crane is identified during the works, they should be stopped.
		
<i>Figure 5. Placing a floater of a Formex® raft (weight: 2.750 kg)</i>		

Knocks and blows of the load manipulated against other objects	Improper placement of the crane or elements lifted	<p>Propper and accurate planning of the handling of the elements, considering all the construction steps. The crane driver should have an adequate visibility of the load lifted, and, if not possible, it should count with auxiliary support. The crane driver should position its cable vertical over the center of the load to be charted to avoid movements with the lifting. The equilibrium should be verified with a minimum lifting in its location. The driver will only lift and manipulate the load under the orders of the rigger (always with the required expertise). Avoid dragging the loads. Avoid working with wind speed higher than 50 km/h. Finally, the load of the truck must be adequately trimmed to avoid movements caused by an accidental knock.</p>
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Figure 6. Left: Formex® frame adequately manipulated. The rigger uses a rope to guide the load and the weight is equilibrated using the required slings. Right: Truck with load appropriately trimmed



Figure 7. Formex® frame being lifted slowly to verify the equilibrium of the loads before staring the process

Rollover of the crane	Excess of load related to the position of the telescopic arm	Adequate planning of the loads and distances that will be manipulated with the crane. The driver must know the approximate weight that the crane is carrying. This work should be done together with the company that rents the cranes, which has the required expertise interpreting the load chart. Besides, the floor should be flat and have the adequate loading capacity (otherwise, the load chart of the crane does not apply). Avoid the sudden stop of the loads that descend rapidly. The works should not start or should stop with winds speeds over 50 km/h.
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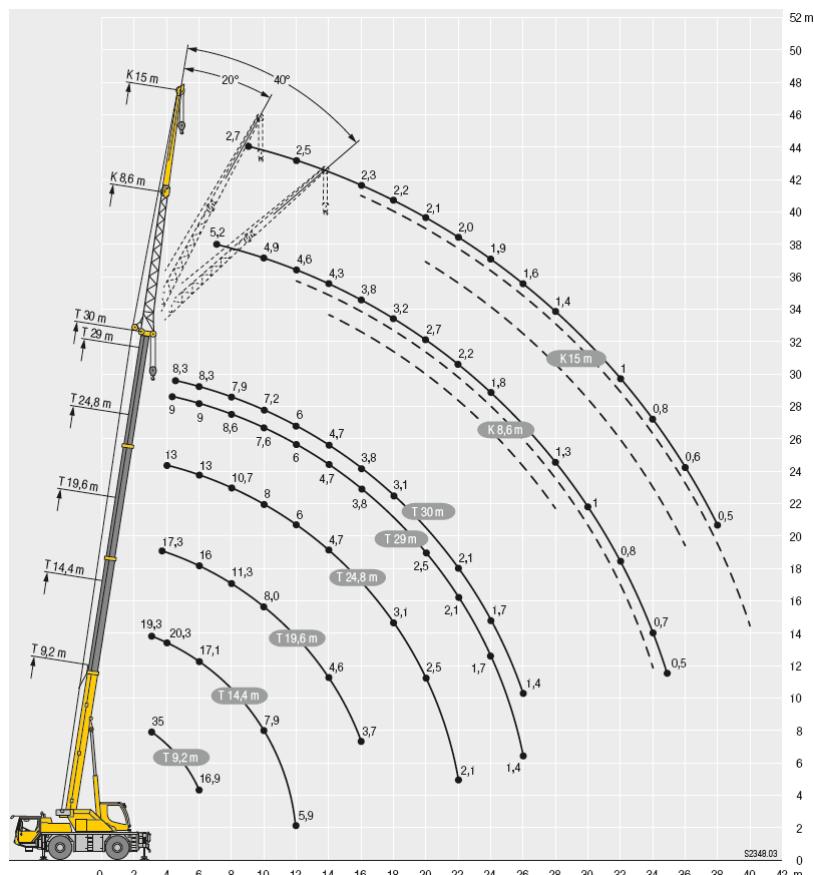


Figure 8. Example of load chart of a 35-t mobile crane (Model: Liebherr LTM-1030-2.1). Source: Liebherr

Runover of people around the crane or the trucks	Inadequate delimitation and supervision of the area of works, combined with a distraction of the driver	The rigger should support the maneuvers of access of the large trucks and cranes. The crane driver must, before starting the path, to inspect the itinerary. The signaling and lighting of the works should be done by the client and according to the Safety and Health Study.
Rollover of the lifting platform	Rollover due to an instability of the ground, an excess of load or the influence of a wind gust	It is forbidden the use of the platform without the required specific training. Besides, it will be used according to the manufacturer's instructions. All the movements must be started slow to avoid rollovers caused by a confusion.

Falling of the workers		
Falling from module surface to the floor	Imbalance, wind gust, slippery surface...	Follow the Non-binding guide to good practice concerning the minimum safety and health requirements for the use of work equipment by workers at work (work at height) [22]
Falling from the stairs	Slipping of the stairs, break, or imbalance	The stairs should be used for a maximum height of 5 m, and never to carry loads over 20 kg. The stair should exceed in high at least 1 meter the location to access. When supported in a vertical wall, it should form an angle of approx. 15 degrees with it (figure 9). The use of the proper footwear is mandatory.

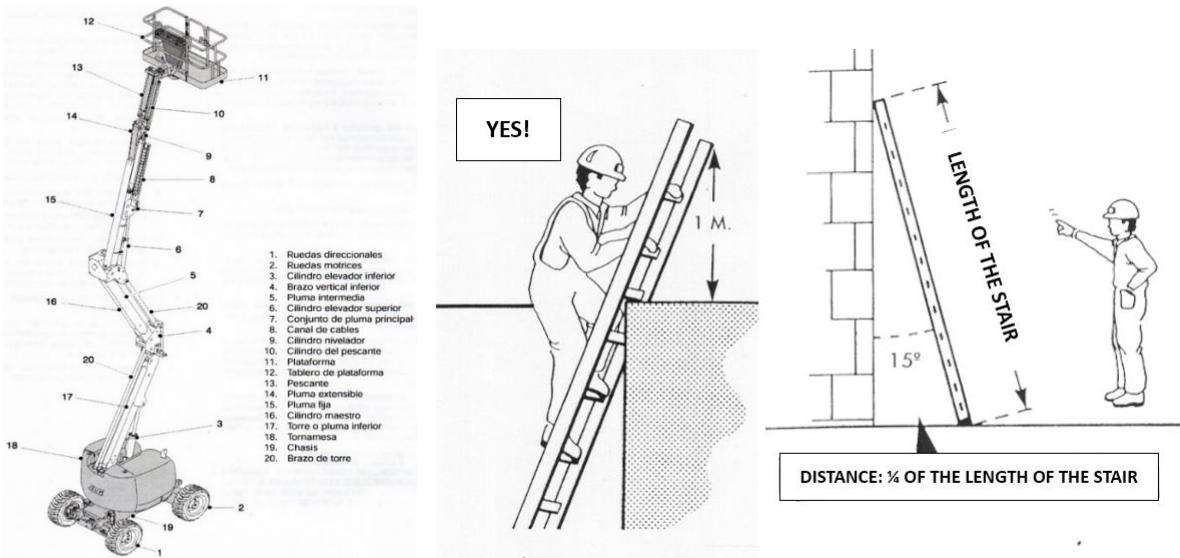


Figure 9. Left: Scheme of a lifting platform; right: Recommendations for the use of stairs

Use of the tools		
Falling from the height of the crane or trucks	Imbalance, wind gust, slippery surface...	Use the available accessories that are in the crane or truck to get into and get out from the crane, and only when the machine is stopped. Verify from the cabin the floor before starting to get out. During the night, light the area of the floor to get out. Avoid using the hook of the crane to access the crane.
Fall of the tools	Fall from the module or fall when a worker throws it to another worker	Do not leave the tools in small locations (beams, balconies, stairs...), storing them always on their final position. Use of special belts to store them for the tools used more frequently. Do not throw tools to other workmates.
Injuries or knocks with the tools	Inadequate use of the tools or use of tools in bad shape	Use of the required personal protection equipment. Use only of approved and reviewed tool, and only by personnel that has been trained for their use. The tools should be unplugged even for short stops. The cut-off disks and drill bits should be the adequate for each material, and they must be replaced only with the machine unplugged. The machines cannot be used with rain or in humid environment, unless otherwise stated. Never use for a work tools that were designed to do other works, as it may harm the user and/or break the tool.
Overexertion	Repetitive loading of heavy loads, or	Use the auxiliary tools designed for each specific case: forklifts, spikes... etc. Follow the recommendations of how to carry weights (see references [16] and [17]). Never turn the trunk loading weight.

	abrupt loading of very heavy load	
Risk of transmission of COVID-19 or others	Works carried out without mask and/or not keeping the required safe distance (1.5 m in Spain)	it is mandatory the use of the mask during the works where the employee can be physically close to other workers. The mask is recommended even when it is possible to keep the safe distance. The use of hydroalcoholic gel is mandatory before and after using common tools. it is recommended to follow an updated Guidance for a safe working environment under COVID-19 situation, as [23], which provides links to the recommendations for different sectors in different countries (considering the high level of research ongoing for a better understanding of the COVID-19, it is recommended to the reader to search an updated guidance)

4. Safety of the floating procedures

There are mainly two different procedures to float a module. The first is using a crane, and it is chosen if the module was assembled in a port or flat area. The second is using the tides and a ramp with access to the water, so it can be used only in regions with a tide higher than 2 m. The constraints of each system are summarized in the table:

Table 4. Difference between the two main procedures to float the modules

	Using crane	Using tidal range
Costs	Higher costs (cranes between 100 and 500 ton)	Lower costs, mainly the vessel used to tow the module
Timing of the procedure	Between 2 and 6 hours	Despite that the module occupies the area during some days, the floating and towing requires workers during only half a day
Timing constrains	Constrained to the permits provided by the owner of the area	Constrained to the period between the high and the low tides
Geographic location	Possible in any region where a large mobile crane is available and has access	Possible only in locations with tidal range higher than 2 m (see figure 10)
Area	Requires a flat pavement with sufficient loading capacity	Requires a ramp or relatively stable area next to the water
Expertise required	Mainly, understanding the behavior and load chart of heavy mobile cranes and the bearing capacity of a pavement	Requires a high expertise in understanding the tide tables and to handle floating structures, because the increase of the tide will make that the module pass suddenly from static to floating conditions
Administrative constrains	Obtaining a license to do the operations may be moderately complex	If the operation does not affect to natural protected area, obtain the license to do the works may be relatively easy.

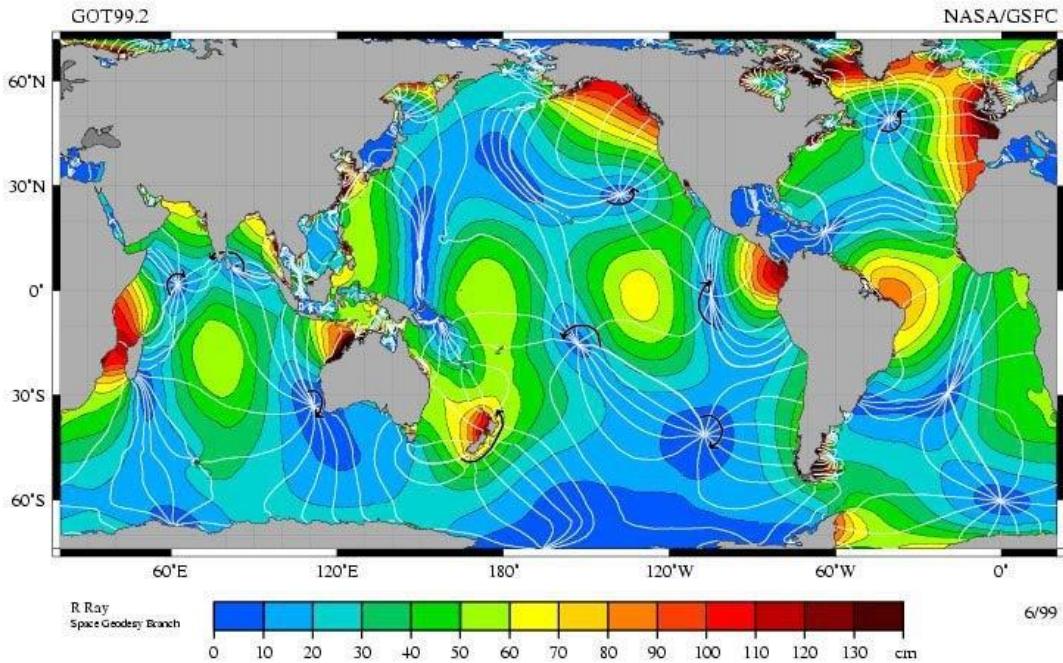


Figure 10. Tidal range global map. NASA/GSFC, Richard D. Ray

Each of the procedures are shown in the figures 11 to 15. Floating the structure with the crane has some of the risks mentioned in the previous chapter (rollover of the crane, failing of the structure, knocks...), but this work is one of the main steps of the installation of a module and it is generally studied in detail, involving the producer of the structure (PREFFOR), the client (which will tow the structure once it is floating), the owner of the area (which has data of accesses and the pavement bearing capacity) and the crane rental company, which has high expertise of the capacity and performance of its machines. Thus, the risks of the operation are low (probability of occurrence) because the severity of an accident would be very high.

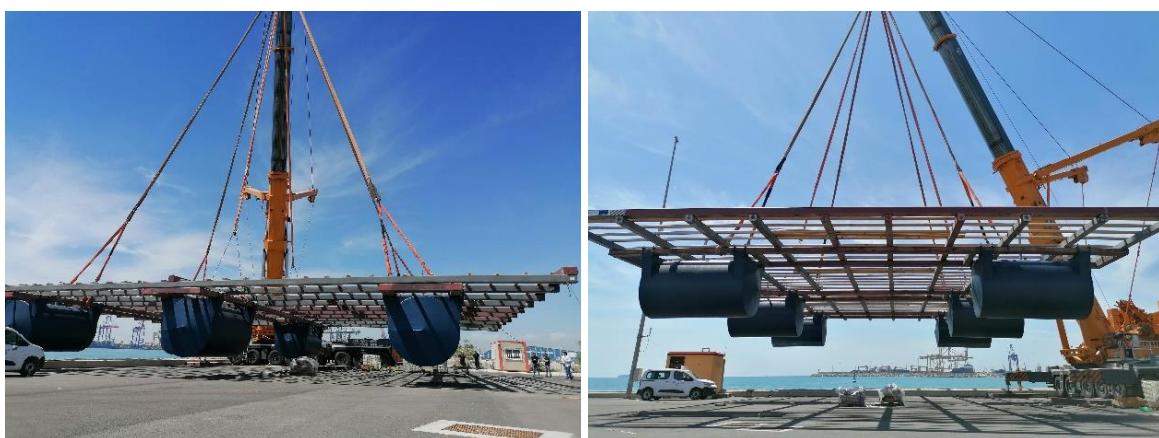




Figure 11. Sequence that shows the floating of a Formex® raft in Valencia port for the H2020 project ReSHEALience-760824

In the case of floating using the tidal range, the high tide can coincide with different meteorological conditions (wind, storm, waves). This implies that it is a less controlled process than floating with a crane, which is only used under favorable conditions. Thus, when using the tide, the module must be adequately anchored to be sure that, if the floating and towing operation is not possible, the module does not drift with the higher water level. Besides, the operators should also access the platform to tie the ropes with enough time to assure that the module will not float. Otherwise, they may be crushed or beaten by a sudden movement of the module.



Figure 12. Positioning of the floaters and primary beams of a Formex® Plus raft in a ramp. Low tide.



Figure 13. Raft assembled one and a half day after starting the work. Tide is starting to rise



Figure 14. Same raft as in figure 13, but two days later, with higher tide. The two mooring ropes to avoid a possible drift of the module can be seen



Figure 15. Formex® Mixta raft after assembling (favourable weather) and farmer towing the same raft under adverse conditions (6 days later, with the arrival of the high tide)

5. Safety of the on-water connection procedure

The design of the connection system between modules was made to facilitate as maximum as possible the procedure of assembling. For this reason, among others, pin connections were avoided. The assembling procedure is recommended with the structures floating on the water, eliminating then the costs of floating a larger structure, which is created on the water. The tools required to do a safe and efficient connections are:

- At least three operators, two over module 1 (moored) and one another over module 2.
- A vessel or boat with capacity to tow one of the modules.
- Four ropes with a minimum length of 25 m and 12 to 20 mm of diameter.

The conditions that are recommended for the operation of connection are:

- Waves: Calmed (glassy or rippled) sea, with a maximum wave height of 10 cm. This implies a degree under the Doublas Sea scale of 0 or 1.
- Current: the water current in the area should be reduced, with a maximum of 0.2 m/s.
- Wind: The wind conditions should be between 0 and 2 in Beaufort Scale
- The modules should be in similar loading conditions to have the primary beams at a similar distance from the water surface. The most adequate is to do the procedure with both structures without harvest (lightship weight).

Table 5. First numbers of Beaufort wind scale

Beaufort number	Wind speed (miles/hour)	Wind speed (km/hour)	Wind speed (knots)	Description	Wind effects on land
0	<1	<1	<1	Calm	Calm. Smoke rises vertically
1	1-3	1-5	1-3	Light Air	Wind motion visible in smoke
2	4-7	6-11	4-6	Light Breeze	Wind felt on exposed skin. Leaves rustle.
3	8-12	12-19	7-12	Gentle Breeze	Leaves and smaller twigs in constant motion
4	13-18	20-28	11-16	Moderate Breeze	Dust and loose paper are raised. Small branches begin to move.
5	19-24	29-38	17-21	Fresh Breeze	Small trees begin to sway

The parameters of waves and currents can be fulfilled assembling the modules in a protected area, as an estuary, a port, or a bay.

The procedure of assembling recommended is described as follows:

1. One of the modules will be moored. This mooring should have the required capacity to stand the larger module that will be created with the connection.
2. In the second module, the operator should use four high-capacity ropes of at least 25-m each. Each rope should have a maximum diameter of 20 mm and have a knot in its extreme with a diameter higher than 35 mm.

3. The operator will use the ropes in the external primary beam of each of the two lines of floaters (marked in red in figure 16). It will pass one rope through one of the diagonal threaded holes of the steel plate. The knot in the extreme will allow to pull the module using the other extreme of the rope. The same procedure will be done with the second rope in the opposite hole of the same plate (figure 18). The same will be done for the plate of the other extreme primary beam.
4. The worker will roll the ropes, preparing them to be launched to the workers that are on module 2. Meanwhile, a vessel should tow the module 2 to approach it to module 1.
5. Once they are close (a distance lower than 10 m), the worker on module 2 will launch the roll of ropes of each primary beam to each of the operators on module 1, which is moored. They will pass the rope through the equivalent threaded holes of the module 1 (figure 19), and they will start to pull progressively and in a coordinated way. The environmental conditions will allow the module 2 to come closer to the 1.
6. Once the plates are confronted and placed in the proper relative position, the worker should keep the rope pulled and insert the first bolt with a nut, screwing without tightening it (figure 20). Later, the next bolt should be placed in the opposite hole of the steel plate. After it, the ropes can be released to insert all the threaded elements of the plates.
7. It is convenient to insert all the bolts of the four connections before tightening them to facilitate a better alignment. After tightening them, the connection procedure will be finished.

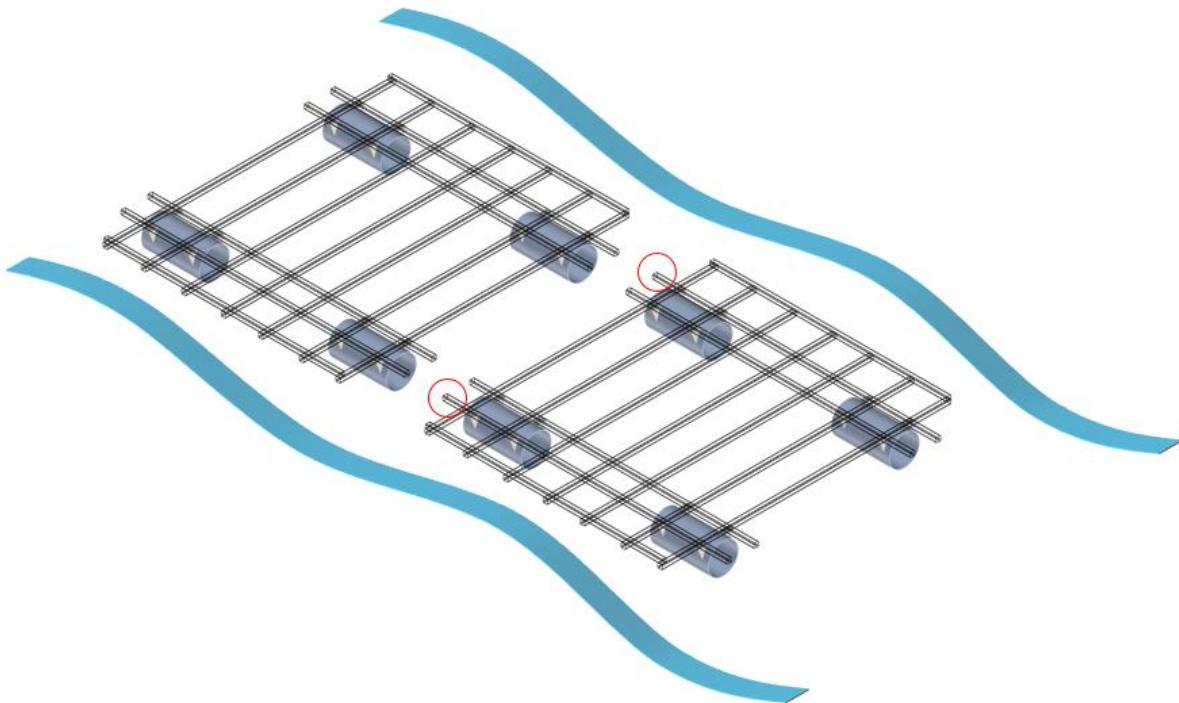


Figure 16. Primary beams that should be used to start the on-water connection procedure



Figure 17. Vessel towing a 540 m² raft

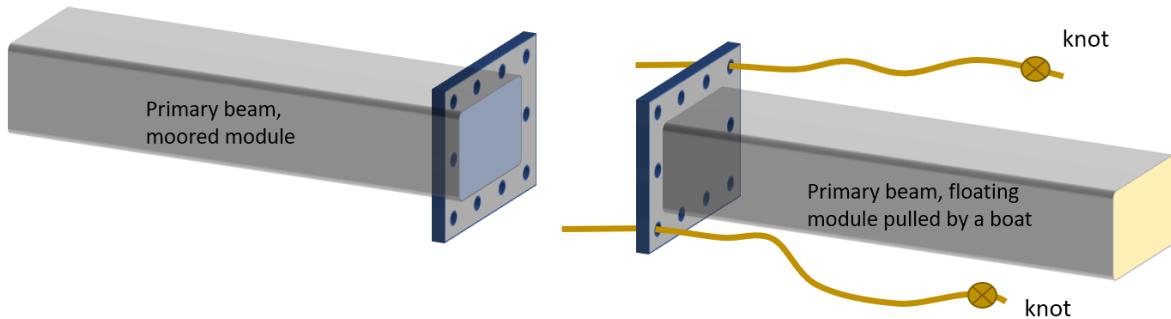


Figure 18. Passing the ropes through the threaded plate of the first module

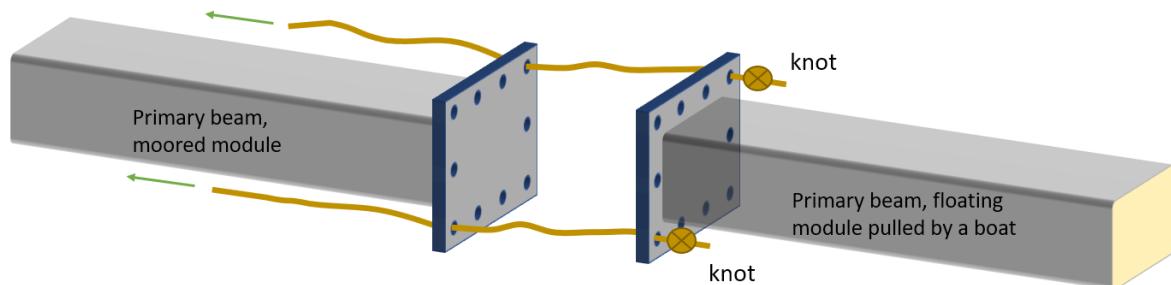


Figure 19. Passing the ropes through the threaded plate of the other module to connect both

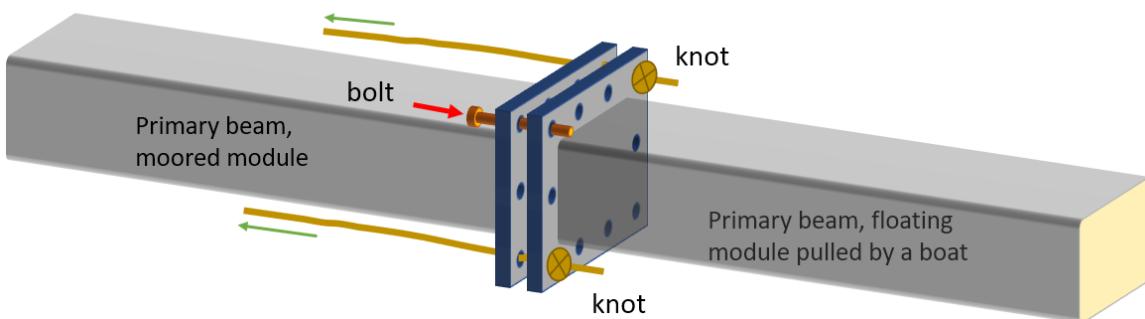


Figure 20. Pulling of the ropes to approach both structures and insert the bolts

6. Maritime safety of the floating module

6.1. Preventive

6.1.1. Beacons

Legal frame

Aquaculture installations, including shellfish farms, are generally located in two different geographic areas: The first are marshes and estuaries, and the second is the coastal area in the maritime-terrestrial public domain, which covers from the coastal line to the 50-60 m in depth [7]. Generally, the installations are moored in locations with a depth from 15 to 50 m, and in a distance to the coastline that does not exceed the 2-3 miles perpendicularly to the coast. These locations are required to make the farming accessible and economically viable for the farmers, but they also may imply a potential risk for the navigation and coastal shipping. To minimize these conflicts to navigation, the non-profit association AISI-IALA was created in 1957. Its purpose is harmonizing aids to navigation. This association elaborates a document that is periodically updated.

Procedure

The beaconing of any aquaculture marine installation, including the modules for mollusc farming, will depend on the established by the competent authority on each country (Puertos del Estado in the case of Spain), which has the competence to accept the type of signals proposed in the beaconing project. There are different scenarios for the beaconing of aquaculture installations depending on what is established by the Lighthouses Commission (adapted from [15]):

- 1) When the marine aquaculture installation may imply a risk for the maritime navigation, it must be beaconed according to the rules of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA AISI, www.ila-asim.org), using for this the following visual aids to navigation: Special marks, lateral marks, cardinal marks, or a combination of them.

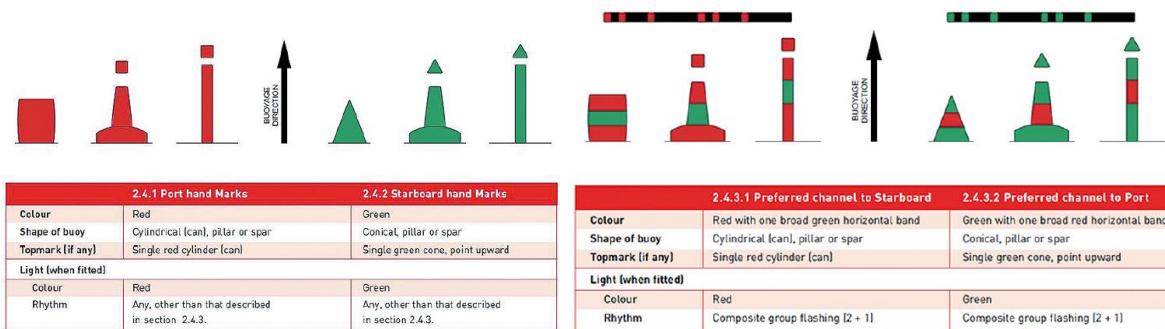


Figure 21. Lateral marks used in region A (Europe, África, and most of Asia)

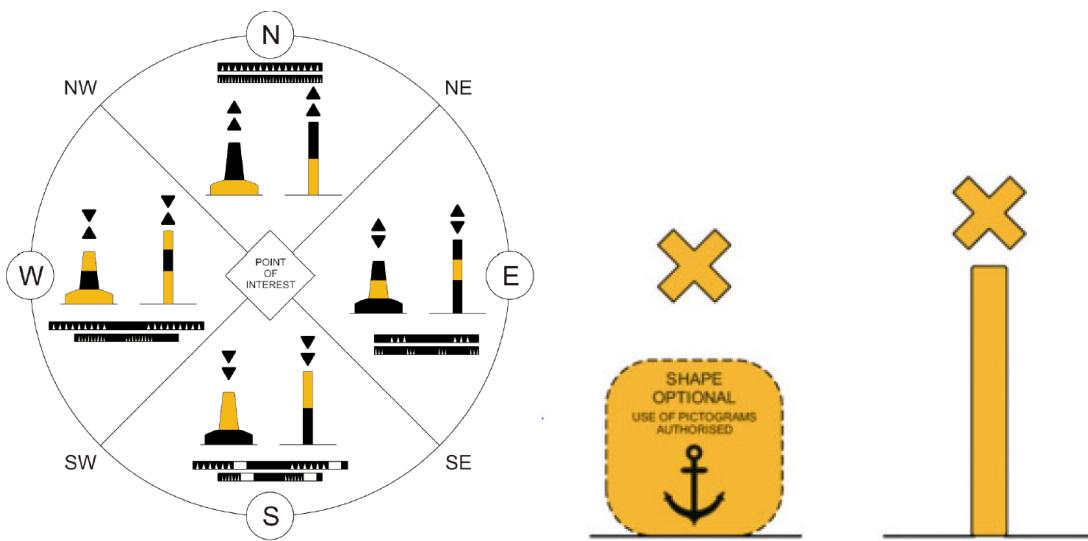


Figure 22. Cardinal marks (left) and special marks (right) according to IALA-AISM

- 2) If the special marks are used, the floating installation should be beaconed using the marks in the apexes of an area that embraces not only the floating element, but also all its mooring system. However, depending on the size of the element it may be enough to beacon only the perimeter of the area covered by the floating element, or simply its centre.
- 3) For isolated facilities with shape of elongated rectangle, it may be convenient to beacon the two longest sides with special marks with different rhythms.
- 4) If there are several marine installations nearby, it is convenient to beacon each of them using different rhythms for the adjacent and following the rhythm of progression indicated by AIS/M/IALA.
- 5) If there is vessel traffic across an installation or between close installations, the channels that will be created for the navigation should be beaconed with lateral marks.
- 6) If the circumstances were to make it advisable, the beaconing may consist only of cardinal marks to maintain the marine traffic far from the floating installation.
- 7) To improve the perception of the beaconing in a marine installation, it must be considered the synchronization of the rhythm of its lights.
- 8) To support the previously mentioned aids, radar reflectors and radio-electric aids, as racons and intensifiers of radar target tracking may be used.

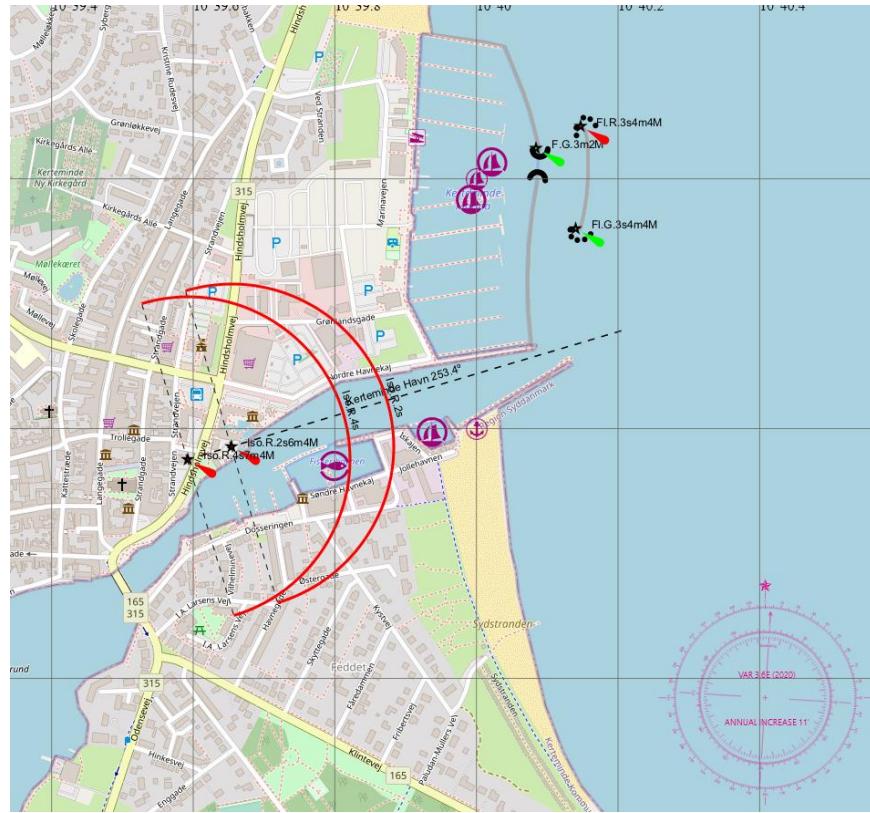


Figure 23. Example of Beaconing in Kerteminde harbour, close to the location where one of the pilot modules of the OpenMode project will be floated. Obtained from the portal <https://map.openseamap.org/>

Example of beaconing of floating farms in Spain

In 1985, Spain decided to adopt for the Spanish waters the beaconing system proposed by the AISI-IALA to avoid any difference between the system in the country and the system used by most of the other coastal countries. This was approved by of the Maritime Safety Committee of the Maritime Consultive Organization (IMCO).

As an example, the case of Galicia (the largest world area with floating farms for mussel farming) is studied here. The mollusc farming areas located in the estuaries in Galicia are not yet completely beaconed. The floating structures are 3.386 divided in 6 estuaries and 44 polygons. Only two estuaries (Baiona, with one polygon [10]; and Muros-Noia, with four polygons [9]) were beaconed in 2015 and 2019 respectively. Their floating structures represent only 4% of all the structures in Galicia. The beaconing installed consists of lighting the four vertex of the polygon and all the locations that are considered risky for the navigation. The light signals used are moored with a concrete block.

The most significant barriers that have prevented the beaconing of the elements are:

- It needs to coordinate several stakeholders, as the Port Authority, Portos de Galicia, General Secretary of the Coast and the Sea, Xunta de Galicia, etc. Annex II includes a description of the legal procedures to do a beaconing project in Spain.

- All the structures were granted more than 30 years ago, and the number of incidents is reduced, so there is no rushing in to accelerating these procedures.

6.1.2. Mooring system

The mooring is the system that avoids that a module goes adrift, assuring that it is always in certain limited area under service conditions. The better defined the location of the structure, the higher the certainty for the navigator and the lower the risks. A module can be moored in multiple ways. The most common are described as follows.

One mooring

The module is moored with a single rope/chain and can move around the area of water in the circle that describes the rope. The longer the chain or rope, the larger the area of the circle that the module can cover. This solution reduces the forces in the mooring because the structure orients to the position with lower forces. This effect can be appreciated in Figure 24. The advantage of this solution is that the pseudofeces of the molluscs are distributed in a larger area than with more moorings. However, there are some additional risks in terms of safety:

- Its location in each moment is less precise than for other type of moorings, so it implies higher risks for the navigation.
- With sudden changes in the environmental actions, the module can move within its circular area at certain speed, which implies a potential risk for fishing boats or the user.
- With a single mooring, there is only one element that prevents the drifting of the element.

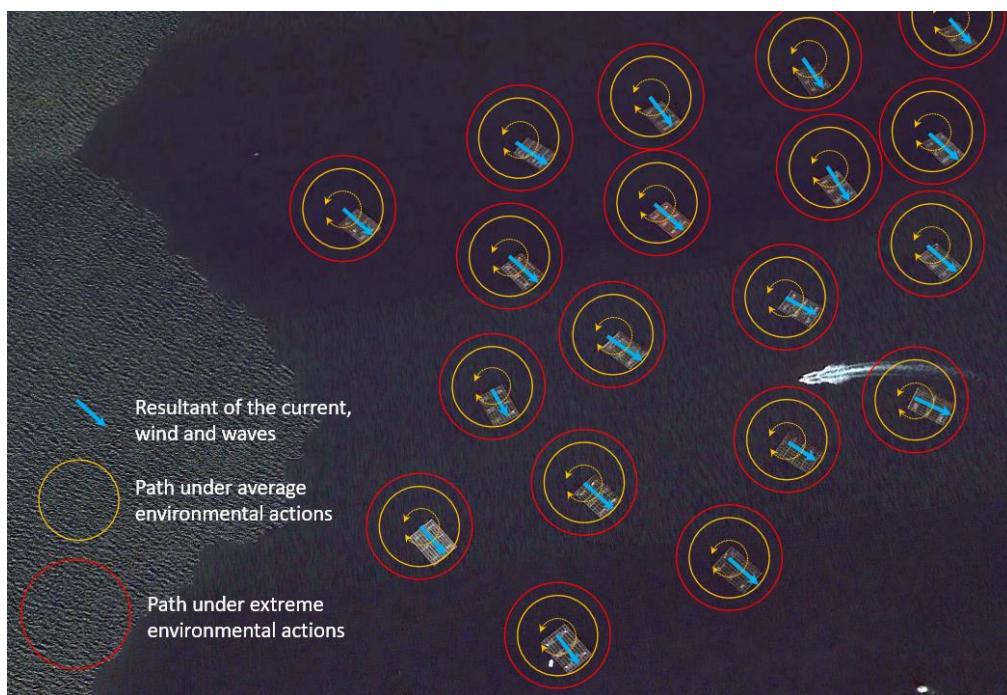


Figure 24. Area of drifting of floating farms in O Grove, Ria de Arousa. All the platforms are oriented in a similar direction because each of them has only a single mooring

Two or more moorings

The most common solution is to have two moorings, one at the bow and other at the stern. This reduces the area drifted by the element, which has an eye shape as can be seen in figure 25. The higher the ratio mooring length/water depth, the higher the size of the eye. In the figure can be seen that the potential area where the modules can be located is much smaller than for the case of a single mooring, being a safer solution for navigation. Besides, the movement on the structure may be smaller, which is safer for the vessel and the operator.

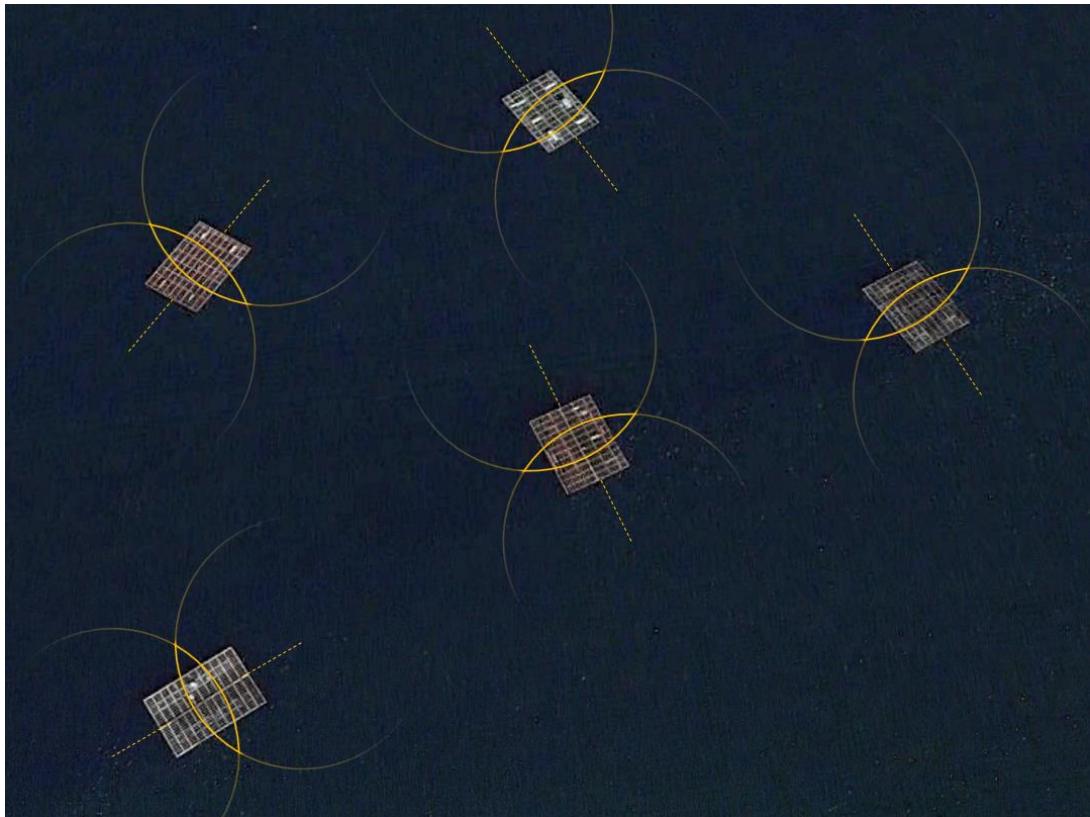


Figure 25. Area of drifting of floating farms in Vigo Estuary. The platforms have the orientation decided by their owner, which is different for each case. The area where the center of the raft can be located is highlighted in bright yellow.

It should be mentioned that the design of the mooring is a critical point to have a safe structure under service. Some of the parameters necessary to design a safe mooring are:

- Accurate estimation of the currents, winds, and waves in the location where it will be installed.
- Water depth and type of seabed (sand, rock, mud...). This will modify the friction coefficient, which will affect to the weight of the concrete block/s required.

6.1.3. Camera

The installation of a camera is, itself, a preventive system that provides additional safety against burglars, vandals or curious visitors that may suffer an accident on the module. The fact of having a camera discourages unauthorized persons to jump on the platform. In the OpenMode project, a

new generation of 360° camera has been designed to control the modules. The details of the different safety systems integrated in it are described in the Deliverable 3.1.

6.2. Corrective

6.2.1. GPS

Having a GPS (global positioning system) integrated in the module provides an accurate position (few meters of precision) of the structure. With a simple software it is possible to know how far is the position of the module from the theoretical position where it has its license, sending an alert if the distance is higher than the radius of the circle that the chain/rope can admit. The activation of the alert is an early warning that the module is adrift and that a team needs to follow the GPS signal to tow it.

6.2.2. Load cell in the mooring

The installation of a load cell in the mooring is a system to estimate the forces in the connection between the chain/rope and the module. Besides of being a system to estimate the forces suffered in the anchoring beam of the module, a continuous value of 0,00 kN may indicate that the mooring has untied. When there is a single mooring, this implies that the structure is adrift. If there are more ropes or chains, the mooring design needs to be inspected and reestablished.

6.2.3. Camera

The camera installed in the module is a corrective safety measure, as it records the entrance of non-authorized visitors, and other incidents that may take place, as the damage of an element, the module going adrift or an employee falling to the water. In these cases, the camera generally will not avoid the damage, but it will be extremely useful for the post-analysis of the situation.

7. Safety under service on the floating module (English)

7.1. Introduction

This chapter can be considered a guide for health and safety working on the module. Considering the potential market in Spain and America, this chapter is also translated to Spanish language.

This point describes the potential risks and safety aspects of a Formex® module, including the protection equipment required under different circumstances that can take place during the service life of the structure (farming, visitors, inspections, reparations...). It is mandatory that the users of the module read and understand this guide or its translation, and it is convenient that the responsible of the structure prepares a simpler sheet or poster to be placed close to the module. Despite that there is a standard Formex® module, each structure installed needs to be visited by an expert in Risk Prevention before entering into service, as the local environment, type of harvest and the local operational resources have an influence on safety. Specific attention needs to be payed to the mechanization of some procedures on the module or on the vessel (not covered here because

it is not part of the module and it depends on the local procedures), which increase productivity but which have safety risks that cannot be neglected.

Besides of the Guide, it is convenient that the responsible of the module consult other documents published in the field of risk prevention in the sea. In the case of Spain, one of the most relevant document are the instructions NTP 624: Occupational Risk prevention in small-scale coastal fishing.

Finally, both the use of the vessels and works on the module take place in areas close to the coast, having the working conditions a rapidly changing weather, which is risky for the employees even if they follow all the recommendations. For this reason, it is convenient in the sector to follow every day the local and regional weather forecast (in Spain, the AEMET, Agencia Española de Meteorología).

7.2. Personal Protection Equipment (PPE) to be used in a module

The PPE that are suggested for their use in a module are described in the following table, which is adapted for the different stakeholders. Green color indicates that its use is mandatory, while the yellow color indicates that it is advisable:

Table 6. List of PPEs that may be required for their use in a module

	Farming steps	Inspections/Reparations	Visits (access only to flat areas > 2 m ²)
Coveralls			
Reflective vest			
Helmet			
Security boots with rubber sole			
lifejacket			
Working gloves			
Sunglasses	Depends on working time and weather		
Sunscreen/cap	Depends on working time and weather		
Neoprene wetsuit	Depends on working time and weather		
Safety harness			
Surgical or FP2 mask			

Besides, for large exploitations, tasks related with carrying weight or under adverse weather, it is convenient that the operators do not go alone to the module (two is the minimum to achieve several safety requirements). As a reference to estimate the number of workers under safe and healthy conditions, Galicia produced (2019) approx. 279.000 ton of mussels with 3890 employees (average of 71 ton/employee). According to information obtained within the framework of the Baltic Blue Growth project [4], it was discovered that 320 man-hours were spent for the maintenance of the farm and to harvest 40 tonnes of mussels a year.

7.3. Novelties of the Formex® module in terms of occupational safety

The Formex® module has been adapted to integrate the preventive and corrective occupational safety measures to guarantee the best working environment for the employees. Different factors as

the working conditions, geographic location and gender perspective were considered for this adaptation. Some of these safety measures are innovations that are under development in the OpenMode project, being a response to the demand identified by different organizations to develop R&D in the field of occupational health and safety in aquaculture [5]. The details of the different sensors developed are described in the confidential document D3.1 (Remote Sensoring). The relevant innovations and differences of the Formex® modules compared to the alternatives are:

7.3.1. Structure

The factors that differ between the Formex® and the wooden rafts are:

- Formex® is an inorganic material, so it does not rot, and the joists cannot suffer a brittle collapse. This avoids the fact that, walking on the module, a worker can break one and knock against the structure or fall into the water (in many cases, with a broken rib that makes difficult to breath and to swim).
- The wooden beams can also suffer brittle failures for different reasons. One is that the material rots, and other the crack created by the bolt of the connection between beams, which damages progressively the connection with a continuous hit. With Formex® this type of failure cannot be suffered because its response in tension is ductile and because it does not suffer volumetric changes with the pressure of the bolts, avoiding the clearances.
- In the Formex® module, the upper surface of the beam has a texture that prevents the slipping that can be experienced when working on it. Besides, the material is inorganic and has high hardness, so if it is covered with algae or organic material it can be easily removed without damaging the surface.
- The Formex® beams are produced with precision and the same properties in the precast plant: This facilitates walking on the structure compared to the wooden structures, where each beam has a slightly different geometry. The long-line (substitutive product) has to be worked from the vessel, having higher risks of overexertion and falling to the water.
- The fact that the beams are precast and totally flat imply that, if it is desired, rails, guides or cranes can be installed to facilitate the works. This is especially useful for the harvest of other species (algae, oysters, clams...)
- The perimeter of the structure can be protected with tyre wheels every 2 m to dampen the impact of the vessel hulk against the material of the module (Formex®), which is hard.
- The risks associated to painting the wooden beams disappear, because the Formex® raft does not require any coating. The risks associated to re-screw frequently the bolts also disappear.
- Both in the Formex® joists and the Formex® beams the edges are rounded to avoid possible abrasions or cuts of the employees. The Formex® joist has the required curvature to minimize the friction of the ropes, besides of having an homogeneous and rough surface finishing to improve the walking over it.
- When the module is made with Formex® joists, it slips less than a wooden platform for the following reasons: 1) The wood gets rotten and slips more than the Formex®, 2) The joists lines

are not geometrically constant as the Formex® joists, 3) The wooden joists can splinter, and this can hurt an operator that is not appropriately protected.



Figure 26. Beams of a Formex® module. The corners are smooth and the surface is homogeneous



Figure 27. Detail of two different surface textures used in the Formex® modules

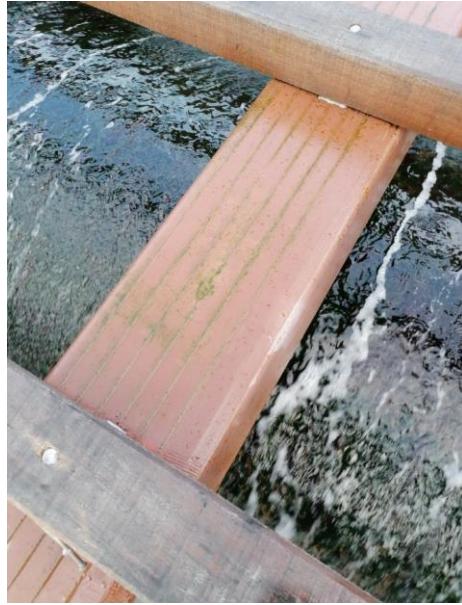


Figure 28. Secondary beams in continuous contact with the sea water. It can be observed a small amount of green due to the continuous contact with the seawater. In Formex®, this can be removed easily than in a wooden beam, which is an organic substrate.

- The precast beams and their standard geometry allow to integrate systems that maximize the operational safety over the module. One of them is the use of four posts with a height of approximately 2.2 m, anchored in a square distribution vertically on the platform. This system fastens a lifeline where the operator can hook a retractable device that blocks the potential fall of the worker. Figure 29 shows a scheme of a possible configuration of this system where the worker has access to all the points of the platform with a cable length of 3.8 m (maximum distance from the center of the module to the closest point of the lifeline plus certain clearance).

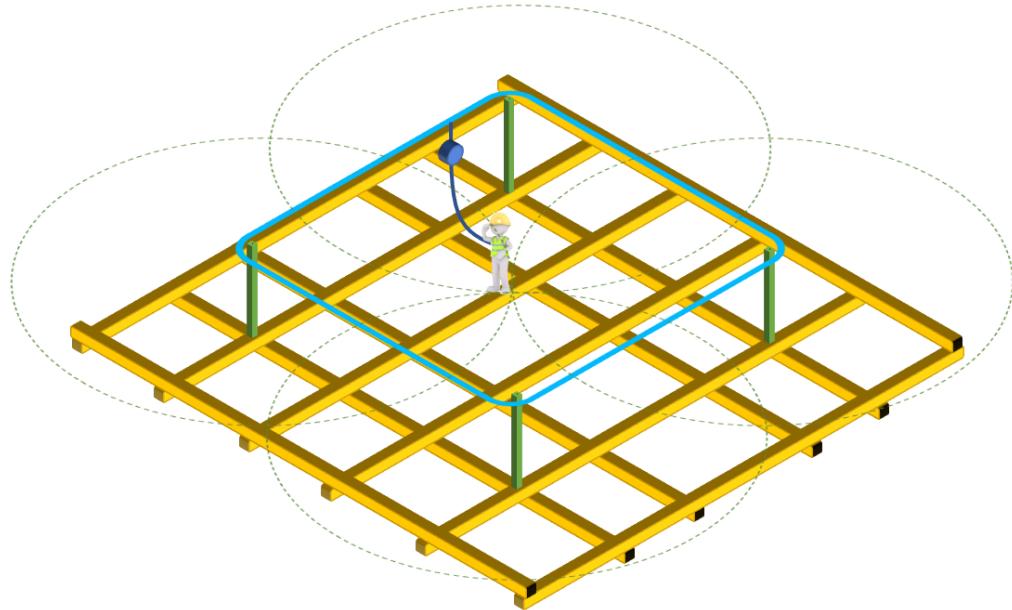


Figure 29. Scheme of the lifeline proposed for a Formex® module. Each side of the structure has a length of 11.8 m

7.3.2. Sensors

- The Formex® module integrates a 360° camera that allows to register the facts that take place on the structure. It can be activated if the farmer wants or automatically under certain circumstances (movement, certain high of waves...). This implies a triple way of control:
 - To avoid burglary on the structure
 - To identify significant damages in their early stage and without inspection risks.
 - To count with more information in case that there is an accident on the raft, so it can be understood better to avoid other accidents in the future.

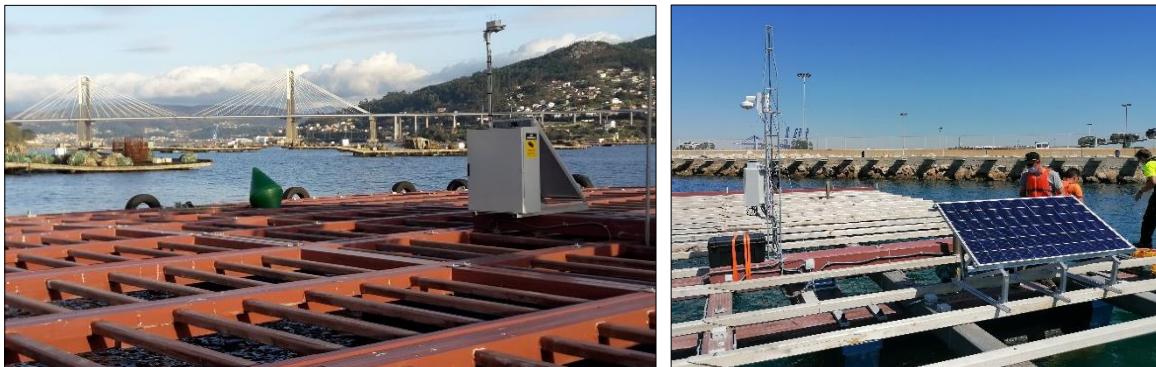


Figure 30. Left: Videocameras installed on the rafts of the project SELMUS-738777. Right: Second generation of videocameras of RDC. Developed in the project OpenMode

- Other systems have been integrated to reduce the unnecessary visits to the module, warn about the adverse weather conditions to work, avoid overexertion, and know if the structure is adrift to avoid incidents with other structures or vessels. These systems are described in detail in Deliverable 3.1 (confidential).

7.4. Risks of operations on the module

The table below describes the most relevant and common risks present in the works on a module. The left column is in different color depending on its risk. The risk is considered the severity of the damage multiplied per the probability of occurrence. The risk can be identified in the colors indicated below:

Table 7. Level of risks considered in the analysis

0	1	2	3
Action not required	Not required to improve the preventive action	Take actions to reduce the risk	Work should not start until reducing the risk

Table 8. Risks identified for the procedures working on a module

Labor risks of farming on a module [13]		
Most common risks of working on a module	Causes	Preventive measures
Risk of falling on the same level and at different level	Falling from the floating module over it or on the water. Falling from the vessel or boat when the worker is embarking or disembarking, or if the boat overturns. The worker can also fall after a dizziness caused by the swell.	Avoid embarking on the module with storm or under adverse weather to avoid dizziness. Use lifejackets on the boat and working on the module. Have on the boat the tools advised and required by the maritime safety sector. On the vessel, in Spain the prescribed Norm is the RD 1837/2000 from November 10 th , approving the Regulation for the Inspection and Certification of civil vessels. The vessel must be in good condition and count with the emergency signals and first-aid kit. The workers should have precautionary measures to access to the boat and in the on-board operations. The loads should be trimmed adequately to avoid unexpected movement of mass on the ship deck caused by a wave. The loads, both on the module and on the vessel, should be adequately marked to avoid accidents. All the workers should use rubber non slip footwear
Falling objects	Stacking of loads, as groups of ropes, boxes, etc.	Do an appropriate stacking of the material in a stable area.
Knocks or cuts with objects or tools	Suffered during the manipulation of ropes, loads or operations on the module	Follow the working procedures established before by the risk prevention department. Use of the required PPE.
Treading on objects	Movement of objects on the vessel or placement of objects in the wrong place on the module.	Maintain an adequate stowage on the boat and keep the desired walkways free on the module.
Entrapment between the vessel and the module or dock.	Fall or mistake during the approximation of the vessel to the structure or dock.	Good condition of the vessel, caution during the access and onboard operations. The employees should wear the lifejacket and have the emergency signals installed.
Risks associated to the exposure to extreme termohigrometric conditions	Significant time working on installations exposed to the weather in different seasons of the year.	Wear appropriate working clothes for the different seasons and change the timetable to reduce the exposure to the hottest hours of the day. Use of sunscreen and accessories against cold. Adequation of the clothes, boots or any other elements used by the worker. Use thermal protective boots when required. Organize breaks of sufficient duration. Finally, having an adequate food to avoid hypoglycemia associated to an intense physical effort with warm weather or hypothermia.
Diving operations: Risk of drowning, overexertion, intoxication, deafness,	The risk can materialize during the works that the divers do over the floating platform, as the inspection of the moorings or chains, etc.	Proceed following the indications of the required training for the medium-waters divers (ascent to the surface respecting the timing, appropriate duration of the stops to avoid the decompression sickness, etc.). Respect the timings of the digestion. Avoid flying during the 24 h after the diving. The diving

hypothermia, nitrogen narcosis...		equipment should have the CE branding (bottles, pressure gauge, weight belt...). Establish a detailed program of permanent control of the diving elements and incorporate safe working procedures to do the underwater reparations and inspections.
Exposure to chemical agents	Possible during the painting or cleaning of the module (in the Formex® module it is reduced because only the joists are made of wood).	It is convenient to use products of the market that are less harmful. The datasheets should be studied in detail, train the workers and provide them with the adequate PPEs.
Accidents caused by animals	They are possible mainly with the birds (seagulls...) around the module	Use an appropriate system to keep the birds far from the floating structure (ultra-sounds, statues, etc.).
Risks during the manipulation of loads, hurting the hands of the employees, abrasion, knocks due to the failing of the load and dorsolumbar injuries	The risks of the overexertion can be associated to the elevation or manipulation of the load, its transportation, or its stowage. On the module are common the overexertion due to the posture manipulating the ropes and the loads [12]. It is caused both by the excess of load and by doing the action repeatedly. Annex III provides a guide of adequate knots to reduce overexertion.	Provide an adequate training in the field of load manipulation. When the worker needs to load an element manually, he/she must stand in front of it, with the feet relatively open and misaligned to assure the lateral and frontal stability. The worker should bend the knees instead of bending the trunk. Never manipulate loads higher than 25 kg. The worker should use the required PPEs (security boots and gloves, especially when the load has cutting edges). The worker should press sufficiently with the hands and have the adequate physical fitness. A complete guide for manual handling can be found in [16] (English) y [17] (Spanish).
Get hooked with a bolt or suffer an impact against it (the worker or the vessel)	Improper placing of the bolt between the secondary beams and the perimeter beam: If the element is placed upside down, the thread is in the bottom part and the person or boat can get hooked.	The 15 mm or 20 mm bolt used to connect the perimetral and secondary beams should be placed to screw the thread in the upper face (figure 31). Besides, it is good that the perimeter of the module is protected with defenses to avoid a potential damage of the vessel hull.
Risk of crushing or damage if the access is done with a small boat.	The worker is on the boat and arrives floating to the area of the primary beams (figure 33), where there is approx.. 50-60 cm of distance between the surface of the boat and the bottom part of the primary beam. If the boat goes behind the beam, the worker tends to bend, but the lifejacket is thick, and he/she can get embedded between the boat and the primary beam. The arrival of a wave in this moment can crush the worker due to the buoyancy of the boat.	If a small wooden boat or inflatable boat is used, it is convenient to tow it in a location far from the primary beams, which are the closest to the water in the module. It is important to tow with enough mooring rope to avoid that the boat gets trapped frequently and facilitate its releasing if there is an incident.



Figure 31. Adequate connection between the perimetral beam and the secondary beams. It can be seen that the thread is at the top side

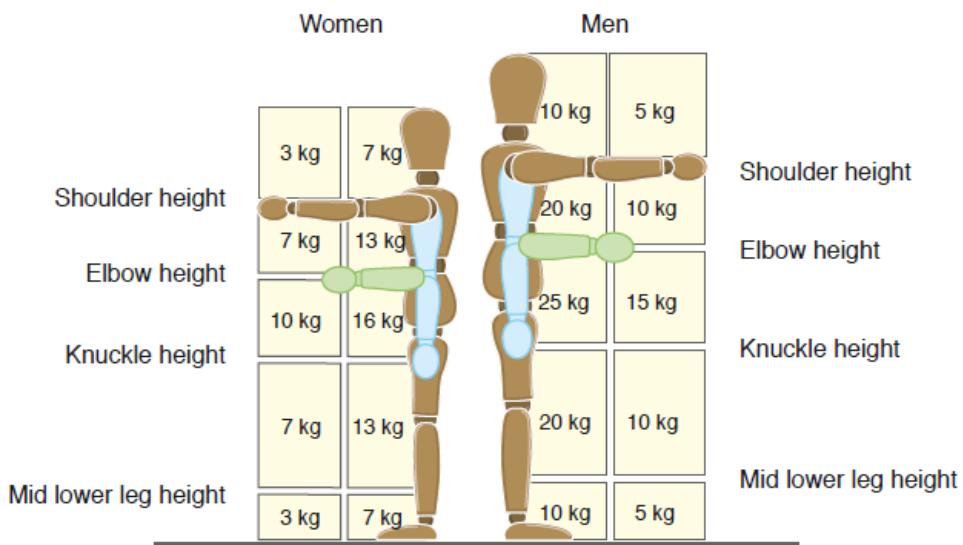


Figure 32. Safe values to reduce the risk of damage handling weights [16]



Figure 33. View of a Formex® raft from an inflatable boat. It can be noticed that the primary beam is, approximately, at the level of the head of the worker.

7.5. Risks of operations on the vessel

In the regions with large intensive farming in floating structures, as Galicia, auxiliary vessels are used for maintenance and care of the harvests. Galicia counts with 1018 registered vessels for a number of 3.386 floating structures of 540 m², which imply that there is approximately one vessel every 4 floating farms (0.55 vessels per 1000 m² of raft).

Generally, the mussel vessels have the bridge on the bow, having all the working deck at the stern. The most frequent is that they are made of steel or wood, with transom and inboard diesel engines. They count generally with an auxiliary engine for the hydraulic requirements. These boats do not have a hold itself, and all the production is carried on the deck. At the stern, the vessel has a far-reaching hydraulically driven hoisting crane. The beam (width) of these boats is significant to improve their stability when this crane works laterally. On the deck are the working tables, in many cases with hydraulic drive. At the stern of the bridge there is a hopper in the upper part to collect the mussels.

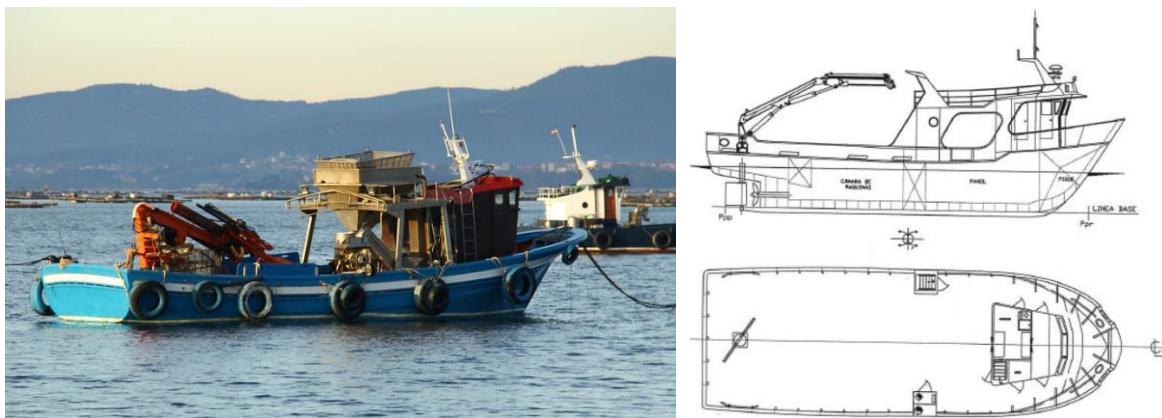


Figure 34. Mussel vessel. Source: Flickr

In a mussel vessel there are several aspects that must be considered in terms of occupational safety. The ship owner must adopt the occupational health and safety measures foreseen in the legislation of on-board Labour Risk Prevention. It should also follow the International Convention for the security of the safety of life at the Sea, 1974 (SOLAS Convention), written by the International Maritime Organization. Among others, the owner should:

- Ensure safety and health of the workers onboard, paying special attention to the weather conditions. Among others, he/she should provide the master of the vessel the necessary means to meet the requirements of the occupational safety.
- Assure that the vessel meets all the conditions regarding the life-saving appliances, both the individual and collective. The lifeboats and life rafts will be available for any immediate need to be lowered fast, even under adverse conditions. The lifejackets must be certified and should worn when required or stored in accessible locations.

- Write a detailed report with the incidents suffered onboard which had or could have influenced the workers' health. This document should be sent to the labour authority, including it also on the ship's logbook.
- Facilitate the periodic controls foreseen in the norms that are under force.
- Assure that the vessel fulfils the minimum security and health conditions established by the law, as the reparations or changes that are done.
- Take the necessary measures to assure the periodic cleaning of the vessel, installations, machines, and devices to guarantee the health and hygienic conditions.
- Have onboard the life-saving equipment in good condition and in the required number and quality.
- Comply and make comply the minimum safety and health requirements using the Personal Protective Equipment (PPE).
- Assure that all the workers receive training and precise information regarding the health and safety onboard, as the prevention and protection measures. This should include the fire prevention, use of the means of survival and rescue, use of the fishing devices, and means of production and signalling.

Besides, there are other relevant factors that must be considered to have a safe vessel:

- Facilitate a simple boarding and landing system from the vessel to the dock or the module.
- Define specific paths for the access of the workers and without obstacles to reduce the accidents and facilitate the access to fire extinguishers or first-aid kits, which should be complete according to the current regulations.
- The employee working on a machine cannot leave the working location with the engine on or with a suspended load. No one can be located behind a raised load, and the worker must also be aware of where the other employees are to avoid moving the load over them.
- Auxiliary machines must be protected to avoid entrapments. After any reparation or maintenance task these protections should be placed again.
- The transmission elements should be protected with guards. The working clothes should be tight and fastened.
- To avoid slipping, oil and fat spills should be avoided on the deck of the vessel or other areas. The handholds and handrails should be free of oil and fat. Special attention should be placed to the risk of burning due to the contact with the hot parts of the machine.
- The load of the vessel during the navigation should be trimmed, especially when it is carrying significant amounts of weight. One of the last accidents in a mussel vessel, the Paquito nº2, was related with this cause. According to the document elaborated by the CIAIM (Commission of the Investigation of Maritime Accidents and Incidents, Ministry of Development, [19]), sailing with an inadequate trimming was unacceptable from the point of view of the maritime safety. Besides, this document mentions that the weight of the load carried on the deck was too high.

7.6. Gender analysis of the use safe use of the modules

To understand the particularities of the gender on floating structures to harvest molluscs, it is necessary to study the platforms that are already ongoing. For this reason, the data provided are from Galicia (Spain), the largest world region with rafts. In this region, the survey of the population employed in marine aquaculture in Galicia [24], from year 2017, shows that from the 3890 employees on the rafts in Galicia that year, only 17.6% (685) were women. The value in absolute numbers has decreased a 35% since 2011, year where the women employed were 1059. Table 9 shows that the sector of mollusc farming is the one with lower percentage of women from the three associated to marine aquaculture in Galicia.

Table 9. Occupation by gender in the different sub-sectors of the marine aquaculture in Galicia. Adapted from [24]

Gender	Rafts (floating farms)		Farming areas		Beds, farms, long-lines		Total	
	Nº	%	Nº	%	Nº	%	Nº	%
Men	3205	82,4%	430	64,62%	476	70,66%	4111	78,62%
Women	685	17,6%	236	35,38%	198	29,34%	1118	21,38%
Total	3890	100%	666	100%	673	100%	5229	100%

From the number of women employed mentioned, the percentage of them doing hard works over the raft is relatively low. A significant part of the workers develops their activity in auxiliary boats, or as workforce for labours as working with the ropes, unfolding the mussel, classifying, or cleaning it... Other women in the sector work in administrative tasks, as managing aspects related with the grant, but not directly in contact with the floating farm.

After having an interview with five different women that work on floating farms (four from Galicia, one from Valencia), some factors have been identified as influential to the scarce presence of women working on the raft:

- The habits, traditions and customs inherited in the region.
- The significant force that is required in some installations, especially in those where the work is mainly manual.
- The distance between the joists of the raft and their width may not be adequate for some of the women, as they are, in average, shorter than the men and they have smaller foot size. A slight increase of the joist width or reducing slightly the distance between them are options that may improve their working comfortability and, thus, their safety.

For these reasons, the following ideas are proposed for the Formex® modules to promote the gender balance in the sector:

- Offer in the range of options of the Formex® module, the possibility to modify the distance between wooden or Formex® joists, adapting it for the final (female) user.

- As the Formex® module is formed by flat precast beams, it is possible to integrate rail or guides on them to install simple cranes or chain hoists that facilitate the manipulation of excessive loads.
- In the trainings for Young students, courses or activities that are going to be developed in the OpenMode Project, it will be promoted the presence in the audience of a significant number of women to show them the attractiveness of the mollusc farming activities. Through this, it is intended to take advantage of the generational replacement to increase the number of women in the sector.

8. Seguridad en servicio sobre el modulo flotante (español)

8.1. Introducción

Este capítulo puede considerarse como una guía de seguridad y salud para el uso del módulo flotante. Considerando el elevado potencial de estos módulos para su uso en España y América, estos apartados han sido traducidos a la lengua española.

Este apartado describe los riesgos potenciales y aspectos de seguridad para los módulos Formex®, incluyendo el equipamiento de protección requerido para diferentes circunstancias que pueden darse a lo largo de la vida útil del producto (cultivo, visitas al módulo, inspecciones, reparaciones...). Es obligatorio que los usuarios del módulo lean y comprendan esta guía o una versión traducida a su lengua, y es conveniente que el responsable de la estructura prepare una hoja o resumen simple que pueda colocar al alcance de los operarios en el módulo o cerca. A pesar de que existe un módulo Formex® estándar, cada estructura instalada necesita ser visitada por un experto en prevención de riesgos laborales antes de entrar en servicio, pues el clima de la región, el tipo de cultivo y los recursos disponibles por la gente local tiene una influencia en la seguridad. Se tiene que prestar especial atención a la mecanización de ciertos procesos en la estructura o en el barco (no se cubren en este documento porque no son parte del módulo y depende del tipo de cultivo y los sistemas de cada región), pues incrementan la productividad, pero pueden generar riesgos a la seguridad que no se deben despreciar.

En lo que a la prevención de riesgos se refiere, se puede consultar, entre otras, las instrucciones de la NTP 624: Prevención de riesgos laborales en la pesca de bajura: artes menores (Occupational Risk prevention in small-scale coastal fishing).

Por último, tanto el uso del barco como los trabajos sobre las bateas se desarrollan en zonas próximas a la costa, por lo que el entorno laboral tiene unas condiciones meteorológicas muy cambiantes y exponen a los trabajadores a riesgos. Por este motivo, es importante prever las condiciones meteorológicas y preparar al personal para las mismas. Se deben consultar diariamente medios fiables de predicción meteorológica (en España, la AEMET, Agencia Española de Meteorología).

8.2. Equipos de Protección Individual (EPIs) que deben usarse en un módulo flotante

Los EPIs que se proponen (algunos obligatorios, otros obligatorios bajo ciertas condiciones y otros opcionales) se muestran en la tabla inferior, que se ha adaptado para los diferentes tipos de personas que pueden tener acceso al módulo. El color verde indica que su uso es obligatorio, mientras que el amarillo indica que es recomendable:

Tabla 10. Lista de los EPIs que se pueden requerir para acceder a un módulo

	Cultivo (diferentes etapas)	Inspecciones / reparaciones	Visitas (acceso solo a zonas adaptadas planas de > 2 m ²)
Mono de trabajo			
Chalecos reflectantes			
Casco			
Botas de seguridad con suela de goma			
Chalecos salvavidas			
Guantes de trabajo			
Gafas de sol	Depende de la duración de las tareas y la climatología		
Crema solar / gorra			
Traje de neopreno			
Arnés de seguridad			
Mascarilla quirúrgica o FP2			

Además, para explotaciones de un cierto tamaño, cuando se precisen manipular cargas significativas o el clima sea adverso, es recomendable que los operarios no acudan solos a la plataforma. Dos personas es el mínimo para alcanzar una situación segura con garantías en ciertas condiciones. Como una referencia para estimar el número de empleados con buenas condiciones de trabajo, se puede destacar que en Galicia se produjeron en 2019 unas 279.000 toneladas de mejillones con 3890 empleados, obteniendo una media de 71 toneladas por empleado. Por otra parte, la información obtenida del proyecto Baltic Blue Growth [4] indica que se requieren 320 horas anuales de personal para el mantenimiento y cultivo de 40 toneladas de mejillones al año.

8.3. Novedades de los módulos Formex® en términos de seguridad ocupacional

El módulo Formex® se ha adaptado para incorporar las medidas de seguridad preventivas y correctivas que crean el entorno más seguro posible para el trabajador, teniendo en cuenta las diferentes condiciones de trabajo, el ámbito geográfico y la perspectiva de género. Algunas de estas medidas de seguridad son innovaciones que se encuentran en desarrollo en el proyecto OpenMode y responden a la necesidad identificada por diferentes organismos de hacer I+D+i en el sector de la protección de riesgos laborales en la acuicultura [5]. Los detalles sobre los diferentes sistemas instalados se pueden encontrar en el entregable confidencial D3.1 (Remote Monitoring). Los diferentes sistemas y novedades que se proponen en los módulos son:

8.3.1. Estructura

Se pueden destacar los siguientes factores en relación a la estructura:

- Al ser el Formex® un material inorgánico, no se descompone y los puntones no pueden sufrir roturas frágiles. Eso evita que un operario caminando lo rompa y se golpee contra la estructura o caiga al mar, en ocasiones con una costilla rota.
- También las vigas de las bateas pueden sufrir roturas frágiles. Esto puede darse porque una de las vigas está podrida o dañada o porque las cabillas se aflojan progresivamente y el traqueteo daña la zona de unión. En el caso del módulo Formex® estos hechos no pueden producirse, pues las vigas son inorgánicas y porque el Formex® no sufre cambios volumétricos por la presión de las cabillas, lo que evita el traqueteo.
- En el prefabricado, la superficie superior se realiza con un texturizado que previene el deslizamiento en el tránsito de los operarios. Además, el material que constituye las vigas es inorgánico y de alta dureza, por lo que si estas se recubren de verdín se pueden limpiar con chorro a presión sin dañar la superficie.
- Las vigas se elaboran en fábrica con una geometría precisa y similar para todas: Este hecho facilita significativamente el tránsito sobre la estructura, pues la estructura alternativa de madera tenía todas las vigas ligeramente diferentes, lo cual dificulta la pisada. El producto sustitutivo, el long-line, no es transitable, con lo que fomenta las malas posturas y las caídas desde el barco.
- El hecho de que las vigas sean prefabricadas y completamente planas permite integrarlas, si se desea, railes, guías o grúas que faciliten la manipulación y tránsito de carga con menos esfuerzo. Esto es especialmente útil para el cultivo de otras especies.
- El perímetro de la estructura se puede proteger con ruedas de goma de vehículo instaladas cada 2 m, lo cual amortigua el impacto del casco contra el material de la batea, que es de gran dureza.
- Los riesgos derivados del pintado de las bateas de madera desaparecen (la batea Formex® no se pinta), al igual que los de reapretar con frecuencia las cabillas.
- Tanto en los puntones Formex® como en las vigas Formex®, los cantos están redondeados para evitar posibles rozaduras o cortes de los operarios. El puntón Formex® con curvatura minimiza el posible rozamiento de las cuerdas, además de tener un acabado superficial homogéneo y rugoso para mejorar el tránsito sobre él.
- El módulo Formex® genera menos resbalones que una plataforma de madera por las siguientes causas: 1) La madera se pudre y es más resbaladiza, 2) las líneas de puntones de madera son geométricamente menos constantes que las de Formex®, por lo que hay mayor incertidumbre en el tránsito, 3) El puntón de Formex® se fabrica con una textura rugosa que lo hace más antideslizante. Por otra parte, los elementos de madera, a diferencia de los de Formex®, pueden producir astillas que pueden herir al operario mal protegido.



Figura 35. Vigas de una batea Formex®. Nótese que los cantos están redondeados y la superficie es homogénea



Figura 36. Detalle de dos texturas diferentes en la superficie de una batea Formex®

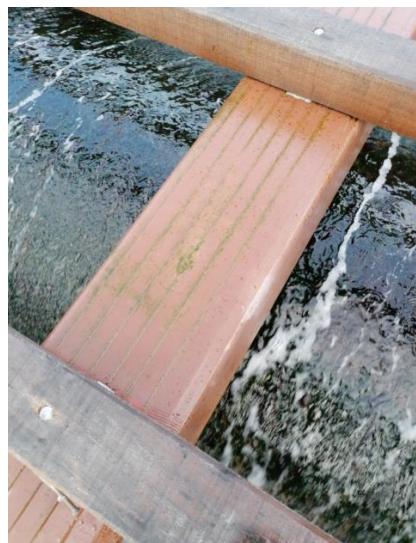


Figura 37. Viga secundaria en contacto continuo con el agua del mar. Se observa en la imagen una pequeña cantidad de verdín en la superficie. Este se elimina con mayor facilidad que de la superficie de la madera, que es un sustrato orgánico.

- Las vigas prefabricadas y geometría estándar permiten incorporar sistemas que maximicen la seguridad en el tránsito sobre la estructura. Uno de ellos es el uso de cuatro postes de anclaje verticales colocados en distribución rectangular en el módulo. Estos hilvanan una línea de vida a la cual el operario engancha un dispositivo retráctil que bloquea la posible caída del operario. La figura inferior muestra un esquema de una posible configuración, en la que, como se aprecia, el operario tiene acceso a toda la superficie de la plataforma. La longitud del cable del arnés debe ser de al menos 3.6 m, que es la longitud máxima desde el punto central de la batea hasta el punto más cercano de la línea de vida. Con esa longitud se pueden alcanzar también las diagonales, que distan de la línea de vida 3.3 m. En la figura inferior se muestran las trayectorias máximas que se pueden abarcar desde cada una de las cuatro esquinas del sistema propuesto.

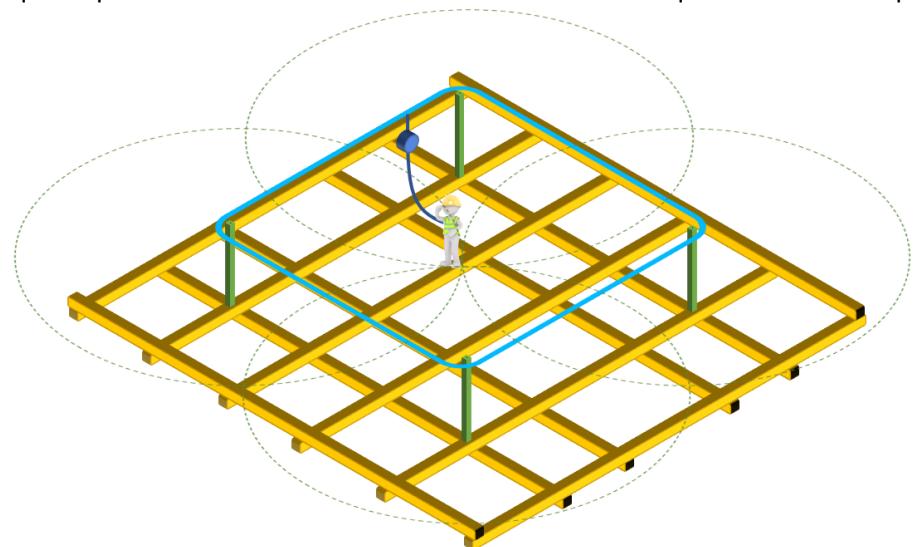


Figura 38. Esquema de las líneas de vida propuestas para un módulo Formex®. Cada uno de los lados de la estructura tiene una longitud de 11.8 m

8.3.2. Sensores

- El módulo Formex® consta de una cámara de video de 360 grados que permite registrar los sucesos que tienen lugar en la estructura cuando el bateero lo desea o de manera automatizada bajo determinadas condiciones (sensor de movimiento, elevado oleaje, etc.). Esto supone un mecanismo de control triple:
 - Para evitar robos en las estructuras
 - Para poder identificar daños significativos de manera temprana y sin riesgos
 - Para contar con más información en el caso de que suceda algún accidente y poder conocer mejor cómo prevenirlos.



Figure 39. Izquierda: Cámaras de video instaladas en las bateas del proyecto SELMUS-738777. Derecha: Segunda generación de cámaras de video de RDC. Desarrollada en el proyecto OpenMode

- Se han propuesto otros sistemas descritos en D3.1 (confidencial) para reducir las visitas innecesarias a la batea, advertir de cuándo esta se encuentra en malas condiciones, evitar esfuerzos posturales y conocer si la estructura se encuentra a la deriva para evitar incidentes con otras estructuras o con barcos.

8.4. Riesgos de operaciones en el módulo

La tabla inferior describe los riesgos más relevantes presentes en los trabajos que se realizan sobre el módulo. La columna de la izquierda indica con color el nivel de riesgo. Se considera riesgo a la severidad de daño multiplicada por la probabilidad de ocurrencia. Los colores se corresponden con los niveles indicados en la tabla inferior:

Tabla 11. Nivel de riesgo considerado en el análisis

0	1	2	3
No se requiere acción	No se requiere mejorar la acción preventiva	Emprender acciones para reducir el riesgo	No se deben comenzar los trabajos hasta que se reduzca el riesgo

Tabla 12. Riesgos laborales asociados a los trabajos de engorde sobre el módulo o batea

Riesgos laborales del engorde en el mar [13]		
Riesgos más comunes en la zona de engorde marítimo	Causas	Medidas preventivas
caídas al mismo nivel y a distinto nivel	Caídas desde la plataforma flotante sobre la misma o al agua. Caída desde el barco a embarcar, desembarcar, o vuelco de la embarcación. La caída también se puede producir por un mareo por el oleaje.	Evitar el acceso a la plataforma bajo condiciones de tormenta o mar excesivamente movida, también por evitar los mareos que esto puede generar. Utilización de chalecos salvavidas en los traslados en barco y operaciones sobre la plataforma. Poseer los medios propios y tipificados para la seguridad marítima. Con respecto al buque, en España debe cumplirse lo establecido en el RD 1837/2000 del 10 de noviembre, por el que se aprueba el Reglamento de Inspección y Certificación de buques civiles. La embarcación debe estar en buen estado y tener la señalización de emergencia y botiquín de primeros auxilios. Debe tenerse precaución en el acceso a la embarcación y a las operaciones que se realicen a bordo. Las cargas deben estar trimadas para evitar movimientos inesperados en la carga causados por un golpe de mar. Las cargas, tanto en la batea como en el barco, tienen que estar adecuadamente señalizadas para evitar caídas. Debe usarse calzado antideslizante.
caída de objetos	Apilamiento de cargas, tales como grupos de cuerdas, etc.	Realizar un correcto apilamiento del material.
Golpes o cortes por objetos o herramientas	En las labores de manipulación de cuerdas, operaciones sobre la plataforma, etc.	Establecer procedimientos de trabajo seguros escritos. Utilización de los EPI adecuados.
Pisadas sobre objetos	Por desplazamiento de objetos en el barco	Mantener una estiba adecuada en el barco
Atrapamiento entre la embarcación y la batea o el muelle	En las labores de aproximación y las que se realicen desde la embarcación	Buen estado de la embarcación, precaución en el acceso y en las operaciones que se realicen a bordo. Llevar chalecos salvavidas y señalización de emergencia.
Riesgos asociados a la exposición a condiciones termohigrométricas extremas	Instalaciones en el medio acuático y en la embarcación expuestas a la meteorología ambiental durante todo el año	Ropa de trabajo adecuada a cada estación y cambios horarios e intensivos para limitar la exposición en las mayores horas de calor. Uso de protectores solares o contra el frío. Adecuación de las ropas, el calzado u otros efectos personales que lleve el trabajador, especialmente en el tiempo de trabajo en las cámaras de frío. Botas con protección térmica o paredes acolchadas. Intercalar tiempos de descanso suficientes. Alimentación adecuada para evitar hipoglucemias por alto consumo energético o por frío.
Operaciones de buceo: riesgos barotraumáticos, sobreesfuerzos, intoxicación, hipoacusia,	En las tareas que realizan los buzos en la plataforma flotante, como inspección del muerto, cadena, etc.	Seguir las indicaciones de la formación requerida por el que se establece el título de técnico en buceo de media profundidad (ascenso respetando los tiempos de permanencia, duración correcta de las paradas para evitar síntomas de la descompresión...etc.). Respetar los horarios de digestión. No volar en las 24 h siguientes a bucear.

hipotermia, narcosis nitrogenada...		El equipo de buceo deberá tener el marcado CE en cada una de las partes que componen el equipo, botellas, nanómetro.... Así como establecer un estricto programa de control permanente de los elementos del buceo e implantar procedimientos de trabajo seguros para la realización de tareas de reparación en profundidad.
Exposición a contaminantes químicos	Durante el pintado de la batea o su limpieza (en la batea Formex® se da poco porque solo los puntones son de madera).	Utilización de los productos menos dañinos posibles. Deben estudiarse al detalle las fichas de seguridad, dar formación y utilizar los EPIs adecuados.
Accidente causado por seres vivos	Principalmente con las aves alrededor del módulo	Utilizar un sistema adecuado para mantener a las aves alejadas de la plataforma (ultra-sonidos, estatuas, etc).
Riesgos en la manipulación de cargas, que pueden generar cortes o abrasión en las manos, golpes en los pies por caída de la carga y lesiones dorsolumbares	Los riesgos por sobreesfuerzo pueden ser debidos a la elevación del producto, a su manipulación, a su transporte o a su estiba. En la plataforma suelen deberse a sobreesfuerzos posturales al manipular las cuerdas y cargas [12]. Se produce bien por el exceso de carga o bien por realizar una carga repetidas veces.	Realizar la formación adecuada en el campo de la manipulación de cargas. A la hora de levantar la carga se debe colocar frente a ella, colocando los pies abiertos y ligeramente desalineados para asegurar la estabilidad lateral y frontal. Flexionar las rodillas en lugar de flexionar el tronco. No manipular cargas superiores a los 25 kg. Utilizar los EPIs adecuados (guantes, especialmente en el caso de aristas cortantes). Hacer buena presa con las manos y tener aptitud física adecuada. Se puede encontrar una guía completa de consejos de manipulación de cargas en [16] (inglés) y [17] (español).
Enganche o impacto del barco contra la batea	Incorrecta unión entre látigo y vigas secundarias, pues la cabilla tiene la rosca hacia abajo y se puede enganchar.	Que la cabilla de 15 o 20 mm utilizada para conectar látigo y vigas secundarias tenga la rosca hacia arriba (figura 40). Que se instalen protecciones en el perímetro de la batea para que un impacto no dañe el casco del barco.
Riesgo de lesión o aplastamiento si se accede con barca pequeña	El operario se encuentra sobre la barca y esta se desplaza hasta la zona bajo las vigas primarias (ver figura 42), dejando tan solo unos 60 cm de espacio en altura. El operario tiende a agacharse, pero el chaleco salvavidas le encaja en ese hueco. La llegada de una ola puede empujar el bote hacia arriba y aplastarle.	Si se usa un bote hinchable pequeño o una barca, es conveniente amarrar esta lejos de las vigas primarias para evitar que se produzca ese fenómeno. Es conveniente dar suficiente cuerda al cabo de amarre para que la barca tienda a engancharse menos, y que si se produce un incidente el barco pueda desplazarse.



Figure 40. Conexión entre látigo y vigas secundarias. Nótesé que la rosca está hacia arriba

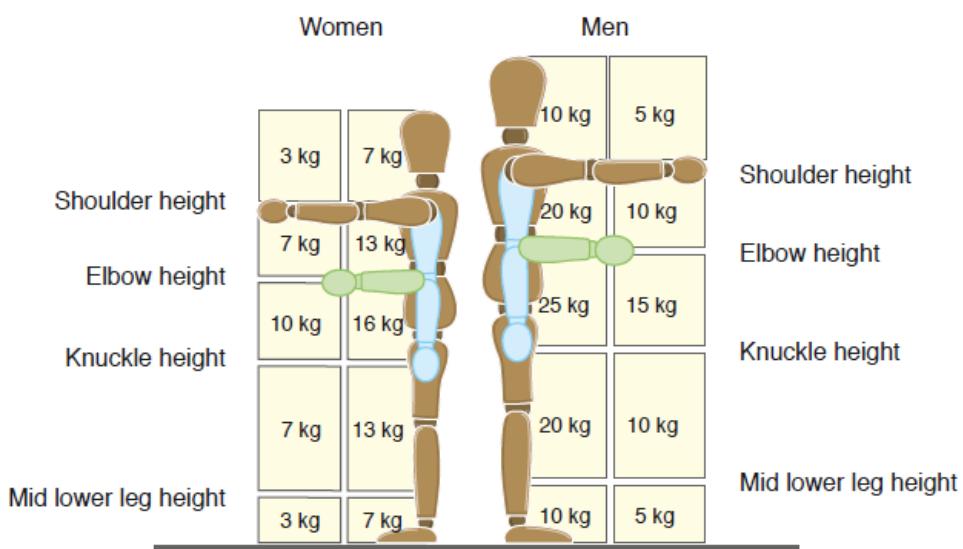


Figure 41. Valores de carga seguros estimados para reducir el riesgo de daño en la manipulación manual [16]



Figure 42. Vista de una batea Formex® desde una barca hinchable. Nótese que el operario está a la altura de la viga primaria

8.5. Riesgo de operaciones en el barco

En regiones con cultivo intensivo en plataformas flotantes, se utilizan barcos para el mantenimiento y cuidado de los cultivos. El mayor ejemplo es Galicia, que cuenta con 1018 barcos registrados para 3.386 estructuras de 540 m², lo que implica que existen aproximadamente un barco por cada cuatro bateas (0.55 barcos por cada 1000 m² de plataforma).

Generalmente, los barcos mejilloneros tienen el puente a proa, dejando toda la cubierta de trabajo a popa. Suelen ser barcos con cascos de acero o madera, con popa de espejo y propulsión mediante motor diesel intraborda. Disponen normalmente de un motor auxiliar para los servicios hidráulicos. Estos barcos no disponen de una bodega en sí, toda la producción se traslada sobre la cubierta principal. En la popa lleva instalada una grúa de accionamiento hidráulico habitualmente de gran alcance. La manga de estos buques grande para mejorar su estabilidad cuando la grúa actúa lateralmente. Sobre cubierta se sitúan mesas de trabajo, en ocasiones con accionamiento hidráulico. En la popa del puente se sitúa una toldilla con una tolva en su parte superior para la recogida del mejillón.

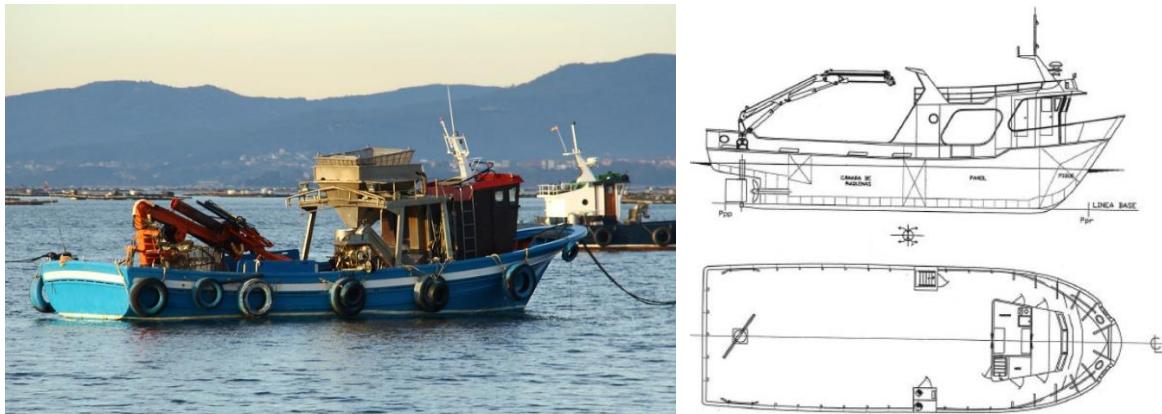


Figure 43. Barco mejillonero. Fuente: Flickr

En un barco mejillonero deben considerarse varios aspectos para garantizar la seguridad. El propietario o armador debe adoptar en materia de seguridad y salud laboral las medidas previstas en la legislación de Prevención de Riesgos Laborales a bordo del barco, cumpliendo además con el Convenio internacional para la seguridad de la vida humana en el mar, 1974 (Convenio SOLAS), elaborado por la Organización Marítima Internacional. Entre otros, debe:

- Velar por la seguridad y salud de los trabajadores que ejercen actividades a bordo, prestando especial atención a las condiciones meteorológicas. Entre otros, debe proporcionar al patrón los medios necesarios para cumplir las obligaciones de seguridad laboral.
- Asegurar que el buque reúne las condiciones referentes a dispositivos de salvamento, tanto individual como colectivo. Los botes y balsas salvavidas estarán disponibles en caso de necesidad inmediata para poder ser arriados con rapidez, incluso con condiciones adversas de asiento y escora. Los chalecos salvavidas serán de tipo homologado y se colocarán en lugares de fácil acceso.

- Realizar un informe detallado de los sucesos que ocurran en la mar y que tengan o pudieran tener algún efecto en la salud de los trabajadores, que deberá transmitirse a la autoridad laboral, registrándolos además en el cuaderno de bitácora.
- Facilitará los controles periódicos previstos en las normativas que sean de aplicación.
- Asegurar que el barco cumple las disposiciones mínimas de seguridad y salud previstas en la legislación, al igual que las reparaciones o modificaciones que se realicen.
- Tomar medidas para garantizar la limpieza periódica de los buques, instalaciones y dispositivos, de forma que se mantengan en condiciones adecuadas de higiene y seguridad.
- Mantener a bordo del buque los medios de salvamento y supervivencia apropiados, en buen estado de funcionamiento y en cantidad suficiente.
- Tomar en consideración las disposiciones mínimas de seguridad y salud relativas a la utilización de equipos de protección individual.
- Garantizar que los trabajadores reciban una formación e información precisas sobre la salud y la seguridad a bordo del barco, así como las medidas de prevención y protección. Esto debe incluir la lucha contra incendios, utilización de los medios de supervivencia y salvamento, utilización de los aparejos de pesca y los medios de tracción, y medios de señalización.

Además, existen otros aspectos significativos que deben considerarse para que el barco sea seguro:

- Facilitar un sistema de embarque y desembarque adecuado hasta el muelle o la batea.
- Definir vías destinadas a la circulación de los trabajadores (sin obstáculos) para reducir los accidentes por caídas y facilitar el acceso a extintores o botiquines, etc.
- Todos los buques deberán disponer de un material de primeros auxilios conforme a la normativa vigente.
- La persona que opere una maquinilla nunca debe abandonar su puesto de trabajo cuando el motor está en marcha o una carga suspendida. No debe situarse nadie en la zona de peligro de izado o arriado de una carga y el operario debe cuidar de no pasar la carga por encima de los trabajadores.
- Las máquinas auxiliares deben tener protecciones para evitar atrapamientos. Tras las operaciones de reparación o mantenimiento, estas deben volver a colocarse.
- Los elementos de transmisión deben estar protegidos por resguardos. Las ropas de trabajo han de ser ajustadas y deben mantenerse abrochadas.
- Para evitar patinazos, se evitarán los derrames de aceite o grasas sobre el piso de planchas. Los asideros y pasamanos deben mantenerse libres de grasa o aceite. Hay que prestar atención al riesgo de quemadura por contacto con partes calientes de la máquina.
- Debe trincarse la carga del barco durante la navegación, especialmente cuando se transportan grandes cantidades en los barcos mejilloneros. Uno de los últimos sucesos con víctimas de un barco mejillonero, el Paquito nº2, se debió a esta causa. De acuerdo con el informe del accidente realizado por la CIAIM (Comisión de investigación de Accidentes e Incidentes Marítimos, Ministerio de Fomento [19]), hacerse a la mar con un trimado inadecuado era inaceptable desde

el punto de vista de la seguridad marítima. Además, este documento estableció que la carga depositada en cubierta era demasiado elevada.

8.6. Análisis de género en la seguridad en el uso de los módulos

Para comprender la casuística del género sobre estructuras flotantes para cultivo de moluscos es conveniente acudir a aquellas que ya se encuentran en funcionamiento, de la que el mayor exponente es la región de Galicia (España). En esta región, la encuesta sobre la población ocupada en la acuicultura marina en Galicia [24], del año 2017, muestra que, de los 3890 trabajadores de las bateas en Galicia en ese año, tan solo el 17.6% (685) son mujeres. El número total ha caído un 35% desde el año 2011, en el que el sector contaba con 1059 trabajadoras. De la tabla 13 se desprende que el sector de las plataformas flotantes de mejillones es el que cuenta con menor representación porcentual de mujeres.

Tabla 13. Ocupación por géneros en las diferentes ramas de la acuicultura en Galicia. Adaptado de [24]

Género	Bateas		Parques de cultivo		Criaderos, granjas, líneas de cultivo		Total	
	Nº	%	Nº	%	Nº	%	Nº	%
Hombres	3205	82,4%	430	64,62%	476	70,66%	4111	78,62%
Mujeres	685	17,6%	236	35,38%	198	29,34%	1118	21,38%
Total	3890	100%	666	100%	673	100%	5229	100%

De las trabajadoras contabilizadas, el porcentaje de las que realizan trabajos pesados sobre la batea es relativamente bajo. Gran parte de las trabajadoras desarrollan su actividad en las embarcaciones auxiliares, ejerciendo como mano de obra en las labores propias de la explotación como el encordado, el desdoble, la clasificación del mejillón, la limpieza, etc. También algunas trabajadoras del sector se dedican a labores administrativas, realizando la tramitación o gestión de los diferentes asuntos relacionados con la concesión, sin participar en las tareas propias del cultivo del mejillón.

Tras conversar con cinco mujeres del sector que trabajan sobre plataformas (cuatro de Galicia, una de Valencia), se pueden destacar los siguientes factores como los causantes de una reducida presencia de las mismas en el sector:

- Los usos, costumbres y cultura heredada en la región.
- La elevada fuerza que se requiere en algunas instalaciones, en especial aquellas en las que se trabaja de manera más manual.
- La distancia entre los puntones de la batea y su anchura puede resultar inadecuada para algunas mujeres, pues de media tienen menos estatura y utilizan una menor talla de pie. Un ligero incremento del ancho del puntón o reducir un poco la distancia entre puntones puede mejorar las condiciones de trabajo.

Por tanto, se realizan las siguientes propuestas para que los módulos Formex® ayuden a promover el balance de género en el sector:

- Ofrecer en los módulos Formex® una variación del producto con diferente distancia entre los puntones de madera o Formex®, adaptado a la usuaria final.
- Dado que los módulos cuentan con vigas completamente planas, se pueden incorporar railes o guías sobre las que colocar un polipasto que facilite la elevación de las cargas que sean excesivas.
- En los trainings para jóvenes, cursos y actividades que se van a desarrollar sobre los módulos durante el proyecto OpenMode, se tratará de promover la presencia de audiencia femenina para mostrar el atractivo del cultivo de moluscos. Se pretende así aprovechar el relevo generacional para incrementar la presencia de mujeres.

9. Food security (English)

Although it is not the focus of this document to develop the topic of safety for the final consumer, here it is briefly described that there is a classification of the different farming areas for molluscs depending on the content of different bacteria (faecal coliforms and E. coli) on the samples extracted. The classification is as follows [20]:

- Class A: The molluscs can be consumed directly (<230 E. coli every 100 g of meat and intervalvular liquid and absence of Salmonella).
- Class B: The molluscs extracted must be purified (removing the bacteria that are present in the molluscs to be cleaned), or purifying them in a Class A area or boiling them adequately before selling to the customer. Class B regions have a content of E. Coli between 230 and 4.600 every 100 g of meat and intervalvular liquid.
- Class C: When the mollusc in the area has between 4.600 and 46.000 of E. Coli every 100 grams. The molluscs need to reinstall during at least 2 months to change to Class A or B or be treated with temperature.
- Prohibited area: Area where it is forbidden that the molluscs are sold for human consumption.

The local or regional authority generally collects the samples of mussel in its farming areas to test them in its laboratories. In the case of Galicia (Spain), this is done through a continuous surveillance network that controls the presence of accelerated growth of toxic dinoflagellates. The presence of paralytic shellfish poison (PSP), amnesic shellfish poison (ASP) or Diarrhetic shellfish poison (DSP) is controlled. When its presence is detected, the collection and commercialization of the mussel from this polygon is forbidden.

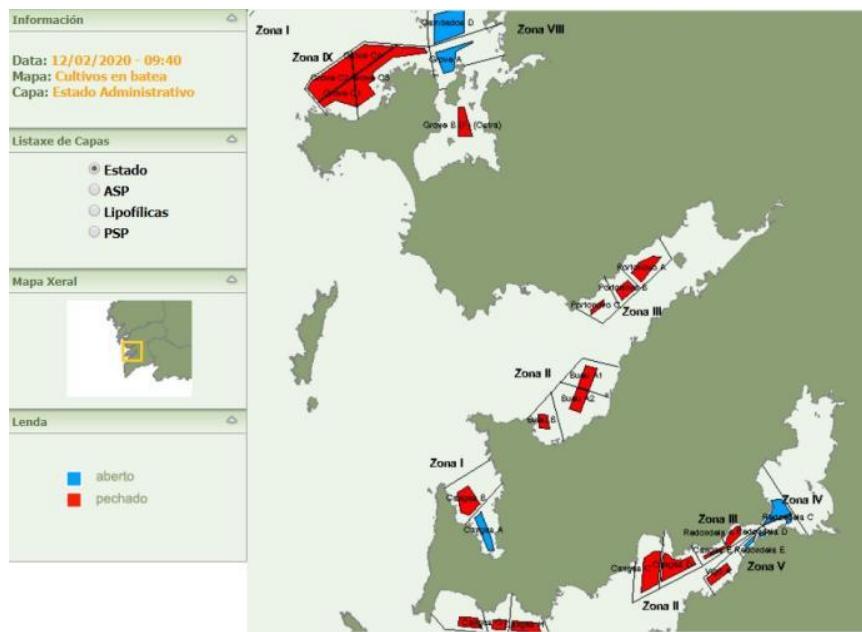


Figure 44. State of the farming polygons in Galicia on February 12th, 2020 (blue: Open polygons (A or B class). Red: Closed polygon for being in Class C).

10. Seguridad alimentaria (español)

Aunque el objetivo de este documento no es tratar la seguridad para el consumidor, se aclara brevemente que existe una clasificación de las diferentes áreas de cultivo de molusco en función del contenido de ciertas bacterias (coliformes fecales y E. coli) en muestras de mejillón extraído. Así, se clasifican como [20]:

- Clase A: Los mejillones se pueden consumir directamente (<230 E. coli por 100 g de carne y líquido intravalvar y ausencia de Salmonella).
- Clase B: Los moluscos extraídos deben ser purificados (eliminando las bacterias en una unidad de depuración aprobada), o bien purificados en una zona Clase A aprobada o bien cocidos adecuadamente antes de ser vendidos para consumo humano. Para que la zona sea de Clase B el contenido de E. coli debe situarse entre 230 y 4.600 por cada 100 g de carne y líquido intravalvar.
- Clase C: Se da cuando el molusco de esta área tiene entre 4.600 y 46.000 E. coli por cada 100 gramos. Los moluscos deben reinstalarse durante al menos 2 meses para pasar a ser Clase A o B, o ser tratados con calor.
- Zona prohibida: Zona en la que está prohibido que sean cultivados para consumo humano.

La autoridad Local es la que generalmente recolecta las muestras de mejillón de sus áreas de cultivo para ensayarlas en sus laboratorios. En el caso de Galicia, esto se realiza mediante una red de vigilancia continua que controla la presencia de crecimientos exagerados de dinoflagelados tóxicos. Se controla la presencia de las toxinas paralizante (PSP; paralytic shellfish poison), amnésica (ASP Amnesic shellfish poison) o diarreica (DSP, Diarrhetic shellfish poison). Tan pronto como su

presencia es detectada, se prohíbe la extracción y comercialización de los moluscos procedentes de ese polígono.

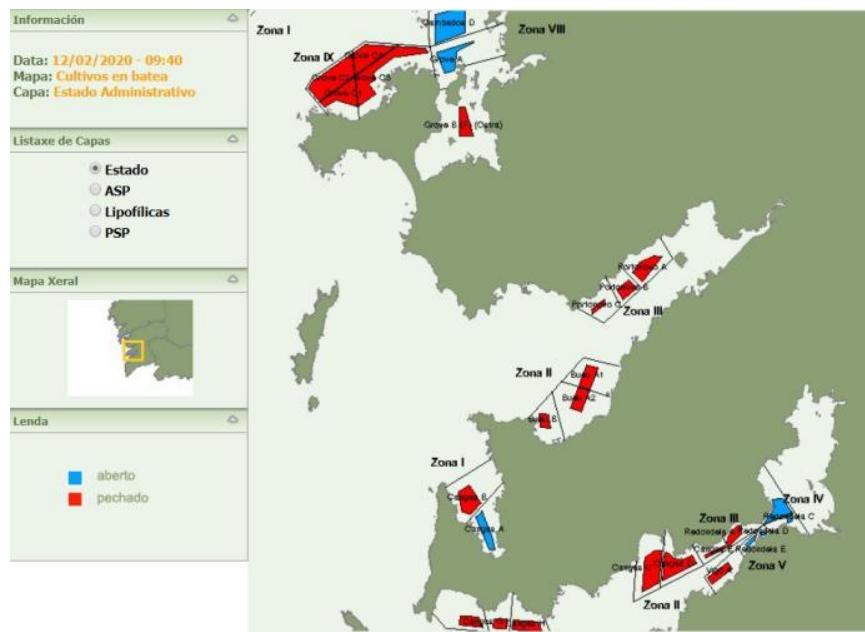


Figure 45. Estado de las zonas de cultivo en Galicia el 12 de febrero de 2020 (azul: Polígono abierto (en clase A o B). Rojo: Polígono cerrado por alcanzar clase C).

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Annex I: Brief description of the production cycle of molluscs in an intensive floating farm

Mussel

The intensive farming system for mussels was introduced in 1946 in Galicia, the region where it has developed to become one of the most productive per square meter known up to this moment. The sector produces every year an average of 240.000 ton of mussel, which implies an efficiency of 131 kg/m² occupied each year. The system is used also with different forms in Canada, US, Japan, Namibia and South Africa. The mussel farming process in a floating farm is generally divided in the following steps [adapted from 21]:

- The procedure generally starts with the collection of small wild mussels in the natural environment [3]. The obtention of the mussel seed (named “mejilla”) can be done in two different ways:
 - Using ropes that the farmers use as collectors on the rafts or modules. The ropes are launched to the sea in the spawning period of the mussel (between March and July), so the larvae get attached to it. On these rafts there are male and female farmed mussels which will pour their gametes to the sea, where the fecundation will take place to create the larvae that will arrive to the stones of the coast, assuring then the repopulation.
 - Since December, directly collecting the seeds from the natural environment. The process implies to pull off the mussels from the rocks with scrapers and transporting them to the raft to place them later on the ropes.
- Placing on the ropes: This procedure consists of attaching the mussels to the rope. The seeds with the required size are placed on the ropes of the rafts. This is done placing certain quantity of the seeds around the rope and inserting a thin mesh around them along all the rope, which has the goal to sustain them to it until they can do it by themselves. These ropes with the seeds are immersed, hanging from the module. The net disappears in few days.
- Unfold of the ropes: After a period of 4 to 6 months it is required to unfold the ropes, as they multiply their weight per 10. With this process it is avoided that they fall from the rope due to the adverse weather and that all of them reach a similar size when they are collected. To do so, the process of unfolding divides the weight of the ropes in two or three new ropes. This process implies that the mussels are transported to a boat using a crane and then scrubbed over a table with a sieve that separates them in different sizes to be reinstalled. After this, they grow better, faster, and more uniform.
- Harvesting and selection: This process takes place a year and a half after the beginning of the cultivation, when the mollusc reaches an optimum size to be sold. In Galicia this period covers from October to March, when the demand is larger, and the mussel has its best conditions. However, if a high percentage of the mussel is spawning or close to it, the harvesting should be delayed. For the harvesting it is useful to use cranes, rakes, and sticks. After this, the mussels are separated and classified, removing the small ones, the mud, empty shells, or other animals.

The mussels that are small to be sold are used again in other ropes, and those that are ready are packed in nylon bags and sent to purification plants (when required).

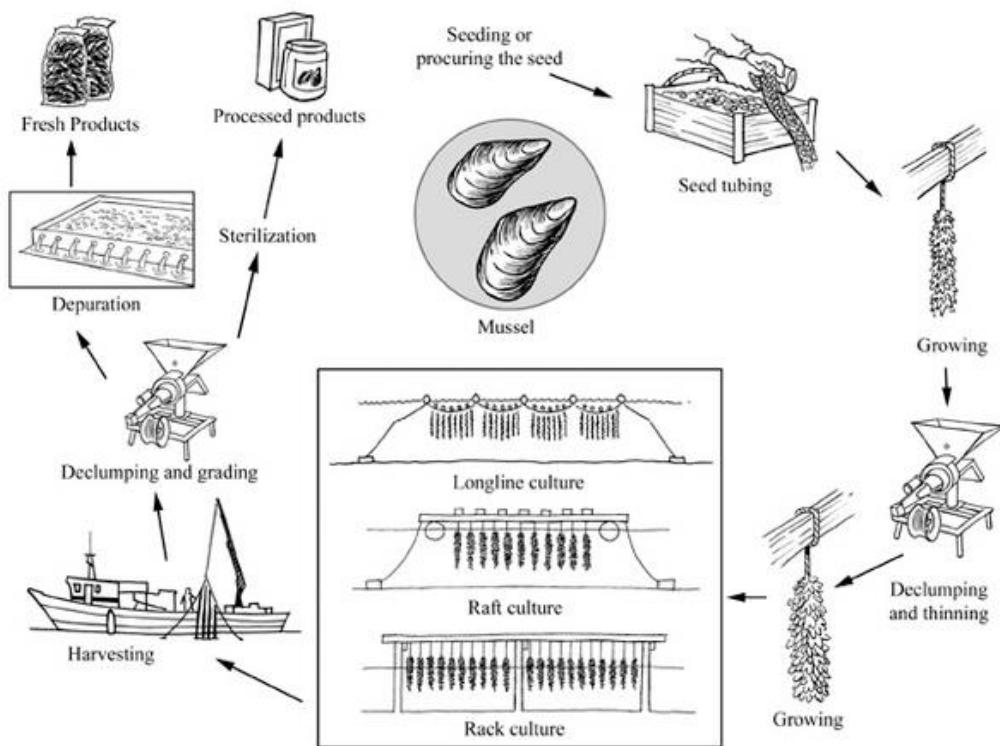


Figure 46. Process of farming the mussel on floating farms and other systems (source: FAO)

- Depuration: This step is required by the environmental regulation to remove the possible contaminants. The mussels are several days in tanks with clean seawater.
- Commercialization and transformation: The mussels are transported for their fresh consumption or to be transformed (preserved, canned, vacuum-packed...).

Oyster

The process to harvest oysters or scallops is more variated and differs from the mussel farming. In some occasions, there are collectors on the sea that are used as substrate for larvae. This process has a significant variability depending on the year. For this reason, currently the trend is to use techniques of captive breeding. This facilitates the homogeneity of the process and the quality of the supply that is required to complete adequately the production cycle.

For the oyster farming the steps replicated are the same than the described previously for the mussel farming. The growth of the seed until having certain size is done in lanterns (named "cubanitos") and has a duration of approximately two months. After this process, they are extracted and glued one by one to the rope with a special cement. They will be 1 to 2 years hanging on this rope until having the optimum size for commercialization.

Clams

The natural farming of clam can also be done in farming modules or rafts, which facilitates the control of the conditions. In this case, as for the cockle, instead of using the rope the seed is planted. The procedure requires that the seeds that are buried in the sand to develop and grow until the first aeration allow its oxygenation. Once they reach their optimum size, they are collected, purified, commercialized, and transformed for their consumption. The same process can be done in the land or on floating platforms.

Annex II: Summary of the legal procedures to propose a beaconing of an aquaculture installation in Spain

To propose the beaconing of an aquaculture installation in Spain, the procedure has the following steps:

1. The concerned presents in the Regional Delegation of the Ministry of Agriculture, Fisheries and Food of its region the aquaculture project, the authorization request of the marine cultures, and a summary of it to be included in the beaconing request.
2. The Regional Government submits the beaconing to Puertos del Estado (Spanish Ports) to request what precise beaconing requires the installation (type of signals, distribution...).
3. Puertos del Estado provides in a maximum of two months the temporary authorization of beaconing, which is sent to the concerned through the Regional Delegation of the Ministry.
4. The concerned must execute the temporary beaconing. Once it is done, it should elaborate the project for executing the works of the temporary beaconing and send it to the corresponding Port Authority.
5. Before the commissioning of the installation and with the beaconing installed, the promoter will inform the Regional Authority and it will inform the Port Authority for an inspection before entering into service. This inspection is not related with the administrative procedure for the grant of the installation.
6. The developer/promoter will communicate to the Instituto Hidrográfico de la Marina (Navy Hydrographical Institute under the Ministry of Defence) the characteristics of this new installed beaconing and its commitment to maintain and control it.
7. Puertos del Estado will start the procedure for the permanent beaconing of the installation.
8. The dossier of the permanent beaconing will be reviewed by the Lighthouses Commission before sending the final resolution to the promoter, the Regional Delegation and the corresponding Port Authority.
9. The promoter must elaborate or update the project of execution for the permanent beaconing and will send it to the corresponding Port Authority. After that, the promoter will carry out the works to install the permanent beaconing approved.
10. The promoter will communicate to the Port Authority the end of the works to do the final inspection. It will also communicate the end of the works to the other stakeholders involved: Regional Delegation, Directorate General for Costs, Maritime Authority and Instituto Hidrográfico de la Marina (Navy Hydrographical Institute) for its communication to the navigators and the modification of the nautical charts and documents.

Who must beacon the installation?

According to the Law 02/2011, Chapter IV, article 137, the service of marine beaconing is responsibility of each Port Authority, and it excludes, among others, the:

c) installation and maintenance of the beaconing of the elements or installations granted, as aquaculture farms and underwater emissaries, or other elements installed in the marine environment and that may be an obstacle for the marine navigation.

d) The beaconing of artificial installations or elements, which should be carried out by their owners, promoters or responsible.

In these cases, the project, installation and maintenance of the beaconing is responsibility of the owner, promoter, responsible or authorised. However, it is responsibility of Spanish Ports to determine, after the expert opinion of the Lighthouses Commission (managed by the Ministry of Development) whether it is required or not the beaconing, defining its fixtures and location.

Requesting a beaconing project requires different documents depending on the country and region, but it generally requires:

- Summary of the beaconing project and brief memory that explains the necessity.
- Dimensioned floor plan with bathymetry of the polygon to be beaconed and the elements with its moorings (A3 size).
- Copy of a recent nautical chart, including the drawings of the installation to be beaconed in its environment (A3 size).

The beaconing project should include:

- The justificatory report of the solution selected, including the calculation of all the elements that assist the navigation and the norms and recommendations used.
- The drawings that define the installation to be beaconed and the aids to navigation proposed.
- Technical specifications required for the navigation aids required, including their installation and maintenance.
- Budget that estimates the work units and most significant items.
- Maintenance plan for the beaconing and contingency plan (accident management guideline).

There is a Spanish Ports network named Portal AtoN (<http://www.puertos.es/es-es/Paginas/Estado-servicio--incidencias.aspx>) which indicates the current situation of the beaconing installed in the Spanish coasts, including the incidences. It includes the beaconing of the aquaculture structures and shellfish farms. As can be seen in figure 47, some of them have the light signal abandoned or destroyed, and the beaconing under service is a radar reflector. The web shows that the experimental farms in open waters in Spain (AZTI, located in Vasc Country) combine for beaconing light signals and radar reflectors in each corner.

Datos de búsqueda

Balizamiento	07.63.01 - VIVEROS FLOTANTES "O GROVE C"
Número Nacional	<input type="text"/>
Autoridad Portuaria	SELECCIONE
Motivo	SELECCIONE
Enviar a la Red AIS	<input type="checkbox"/>
Imprimir Limpiar Buscar	

Resultados (3)

Número Nacional	Nombre	Código de Balizamiento	Nombre	Ayudas Existentes	Detalle
04165	BOYA VERTICE B	07.63.01	VIVEROS FLOTANTES "O GROVE C"		Detalle del servicio
04170	BOYA VERTICE C	07.63.01	VIVEROS FLOTANTES "O GROVE C"		Detalle del servicio
04175	BOYA VERTICE D	07.63.01	VIVEROS FLOTANTES "O GROVE C"		Detalle del servicio

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Señal Luminosa
 Señal Acústica
 Señal DGPS
 Señal Racon
 Reflector Radar
 Señal Ciega
 Señal AIS-AtoN
 Señal AtoN-Virtual
 En Servicio
 Servicios Reducidos
 Fuera de Servicio
 Retirada por temporada
 Servicio Programado
 Abandonada o destruida

Figure 47. Type of beaconing installed in O Grove C, Galicia. In this case, it shows that the light signalling is abandoned or destroyed. Obtained from the Spanish Ports network Portal AtoN.

Datos de búsqueda

Balizamiento	BI.21.00 - AZTI - LONLINE EXPERIMENTAL
Número Nacional	<input type="text"/>
Autoridad Portuaria	SELECCIONE
Motivo	SELECCIONE
Enviar a la Red AIS	<input type="checkbox"/>
Imprimir Limpiar Buscar	

Resultados (4)

Número Nacional	Nombre	Código de Balizamiento	Nombre	Ayudas Existentes	Detalle
00450	BOYA OESTE	BI.21.00	AZTI - LONLINE EXPERIMENTAL		Detalle del servicio
00450.1	BOYA NORTE	BI.21.00	AZTI - LONLINE EXPERIMENTAL		Detalle del servicio
00450.2	BOYA ESTE	BI.21.00	AZTI - LONLINE EXPERIMENTAL		Detalle del servicio
00450.3	BOYA SUR	BI.21.00	AZTI - LONLINE EXPERIMENTAL		Detalle del servicio

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Señal Luminosa
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 En Servicio
 Servicios Reducidos
 Fuera de Servicio
 Retirada por temporada
 Servicio Programado
 Abandonada o destruida

Figure 48. Type of beaconing installed in an experimental longline. All the beacons are under service. Obtained from the Spanish Ports network Portal AtoN.

The portal allows any user to send the incidences detected in a beaconing (figure 49) through a form named Occurrence Reporting for the Navigational Assistance Service. It includes the national

number and the use of standardized concepts. As an example, for visual aids: off, disappeared, destroyed, sunken, irregular, or retired. For radio-electric aids: out of service, etc.

The screenshot shows a software interface for managing maritime beacons. At the top, there is a search bar labeled "Emplazamiento" containing "04485 - BOYA VERTICE A". To the right of the search bar is a "Volver" button. Below the search bar, there are three tabs: "Mapa" (selected), "Satélite", and "Emplazamientos". The main area displays a dark satellite-style map of a coastal or riverine area. A yellow marker indicates the location of the beacon with the number "04485". On the right side of the map, there is a legend with icons for "Mapa", "Satélite", and "Emplazamientos".

Características del faro seleccionado

Número Nacional:	04485
Número Internacional:	SN
Nombre:	BOYA VERTICE A
Longitud:	008° 51.400' W
Latitud:	42° 30.501' N
Color:	AMARILLO
Ritmo:	GpD(4)
Alcance (MN):	3.00
Característica:	[(L 0 5 oc 1 5)3 veces] L 0 5 oc 4 5
Período (s.):	11.00
Elevación (m):	0.00

[Foto](#) [Detalle](#) [\[Lightbulb icon\]](#)

Histórico de Incidencia 1212

Emplazamiento

Número Nacional: 04485	Número Internacional: SN	Nombre: BOYA VERTICE A
Nombre Local:	Longitud: 008° 51.400' W	Latitud: 42° 30.501' N
Tipo de Emplazamiento: OTRAS	Identificador Red AIS:	Balizamiento: VIVEROS FLOTANTES "O GROVE A"

Ayuda Luminosa

Tipo de Luz: Boya	Color: AMARILLO	Ritmo: GpD(4)
Característica (L+Oc): [(L 0 5 oc 1 5)3 veces] L 0 5 oc 4 5	Período (s): 11	Altura soporte (m): 0
Elevación del plano focal (m): 0	Alcance dia (M):	Alcance noche (H): 3

Incidencia - Paso: 1

Motivo: Desaparecida/Missing	Estado Actual: Fuera de servicio	Fecha de Incidencia: 11/01/2013 12:00
Notificado por: Fax No	Creada por: javier	Notificada por: Puertos del Estado
NOTIFICADO POR RED TIMON AVISO NR-21/2013		

Descripción:

Incidencia - Paso: 2

Motivo:	Estado Actual: Abandonada o destruida	Fecha de Incidencia: 28/04/2015 12:00
Notificado por: Fax No	Creada por: javier	Notificada por: Puertos del Estado
[Empty text area]		

[Descripción](#)

[Volver](#) [Salir](#)

Figure 49. Incidences detected in a beacon and reported by a worker of Puertos del Estado

Annex III: Knots to reduce overexertion

The knot to attach the rope to the joist must be strong and, at the same time, easy to untie. Decades ago the most used was the shown at figure 50, but the inconvenient was that to lower the rope it was necessary to rise it with all the load, which requires a significant effort when the harvest is big.

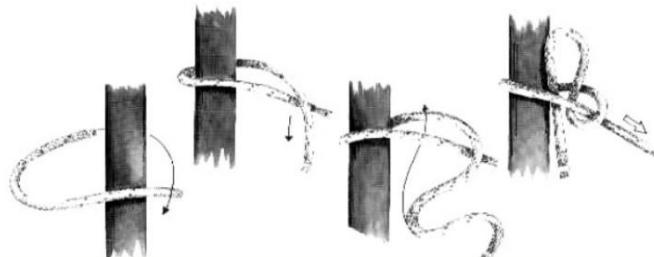


Figure 50. Type of knot used decades ago around the joist

The system used currently due to its comfortability and security, is the knot with two turns around the joist (not “biting” it) and with three tucks around the end of the rope. This is a strong and easy-to-untie knot and avoids that the rope moves through the joist, preventing its abrasion and maintaining the desired length between the columns of harvest.



Figure 51. Mussel ropes on the Formex® raft. Polygon O Grove C2, Arousa estuary, Galicia

In the regions with less intense waves and there where the mussel load per rope is lower, simpler knots as the bowline (figure 53) can be used without risks. This facilitates the tying procedure and the overexertion suffered by the employee (figure 52).

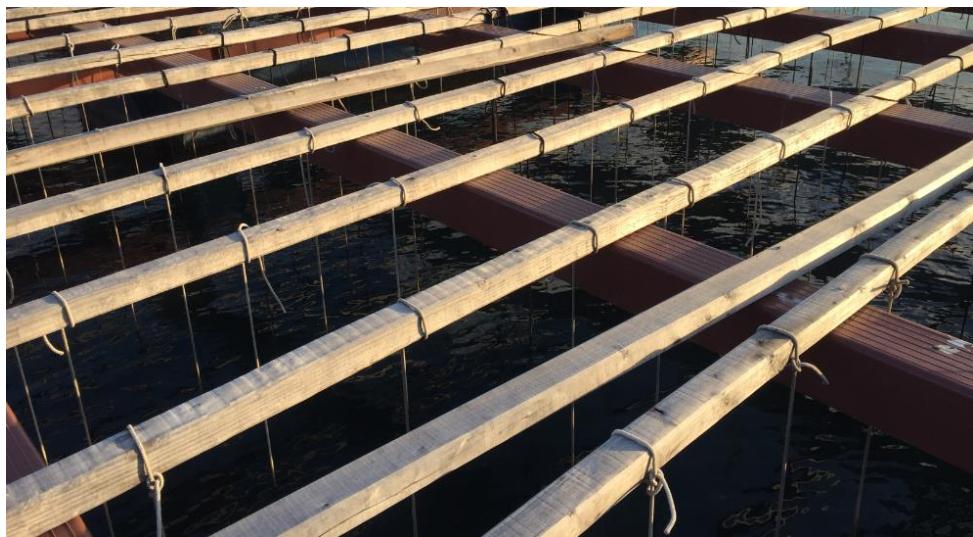


Figure 52. Mussel ropes on a Formex® raft (Valencia port)

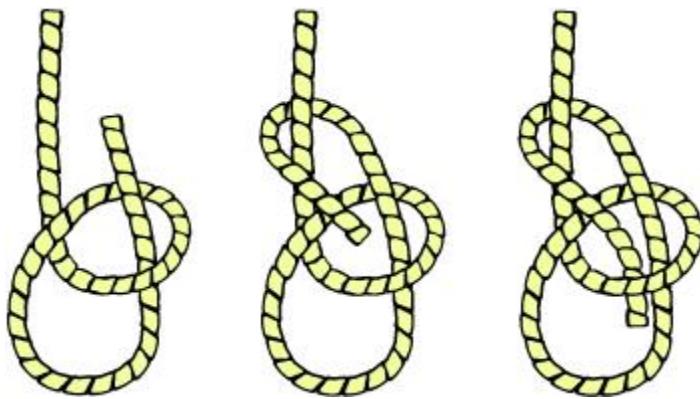


Figure 53. Bowline knot ("As de Guía" in Spanish)