Management tool

Management guide for Marine Protected Areas

Permanent ecological moorings

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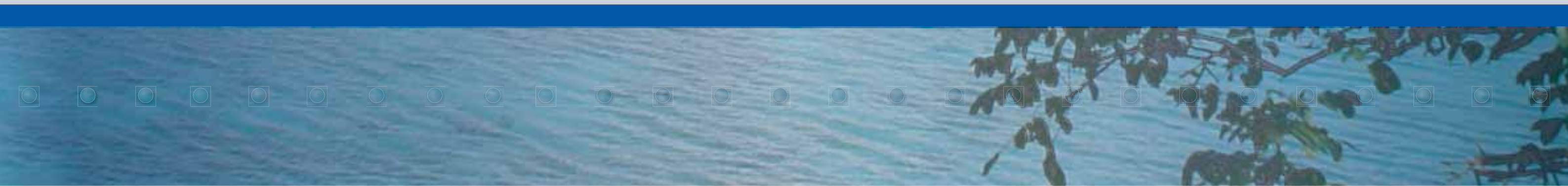
Management guide for marine protected areas of the Mediterranean sea

Permanent ecological moorings



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«Permanent Ecological Moorings» was designed as a guide for managers of coastal or marine areas and for all the administrative and associative structures who face the recurrent problems of moorings. **This guide summarizes key issues and shows the various choices available as well as being a technical guide.** It wants to answer the main questions that one faces while managing the diverse activities involved in mooring and anchorage.

Anchorage or mooring? The authors of this guide have voluntarily considered that the two terms are synonymous . Two categories of anchorage (or mooring) can be defined : **temporary mooring and permanent mooring**. A permanent mooring cannot be moved quickly or easily. A temporary mooring is (usually) an anchor stored onboard a boat (or a floating structure that needs to be clamped down) and is re-hauled onboard when the boat starts to move again.

The act of mooring with an anchor means, dropping an anchor overboard to enable the immobilization of a boat because the anchor falls and is wedged onto the bottom. When removed , this anchor will be pulled up forcibly in order to be freed from the seabed. Depending on the fragility of the seabed or of the sea life (animals or plants) that are developing there, the impact can be significant. The areas most adapted to moorings are dependent on hydrological factors (currents, wave exposure) and meteorological factors (wind exposure). Along a stretch of coast these areas are not especially numerous and the pressure of moorings on the seabed can be frequent and significant.

Every manager or organization in charge of managing a coastal marine area will be facing this choice: **preserve as good as possible the seabed or allow unregulated moorings with all the potential negative results that can ensue**. In addition to general boat use, the managers themselves may need to moor: their own boats, permanent floating structures (pontoon, barge, buoy) or immersed structures (canalization , sign for diving trail). How does one choose in cases like these an ecological solution that has minimal negative impact for the environment?

This guide will help in the choice of the most adapted ecological solution depending on the environment in question. It is divided into two main parts: **the description of the major environments and the technical description of various permanent ecological moorings recommended.**

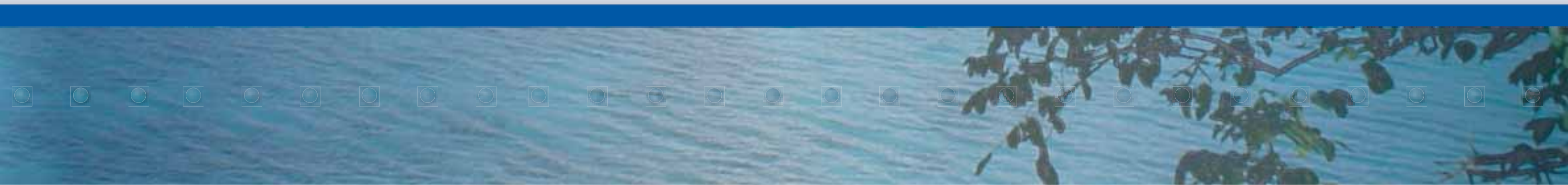
Five main categories of environments have been selected: **Sand and mud, Pebbles and cobbles, Boulders and bedrock, Coralligenous formations, and Posidonia meadows**. Each environment is briefly described and its ecological importance is detailed. The sensitivity and vulnerability of each of these environments are then evaluated depending on their particular characteristics: speed of regeneration, structural complexity (its architecture), ecological role, etc. These elements should enable us to understand why one environment is more or less fragile and why it is necessary to look for alternative solutions to moor with an anchor.

The **technical solutions** include a description of the **immersed parts** (the ones laid on or pushed into the sea bed) and the **parts at the surface** without forgetting the **connecting elements** between the surface and the bottom. Advice on the installation is also given. When many solutions are possible for a given environment they are presented in a comparative table in a synthetical manor that will help the manager to choose the optimum solution taking into account the usage, the quality of the substrate, and the estimated effort involved.

Please note: if this guide shows the various choices between the different technical solutions, in no way does it pretend to be nor replace a technical manual necessary to calibrate the mooring. Further more it does not address the juridical issues attached to problems of authorization or management of moorings.

If the place for a mooring does not need to be at a precise location, a manager might then have the choice between different substrates. In order to help this choice a table summarizes **the vulnerability of each environment**, from the least to the most sensitive and vulnerable.

At the end of this guide three appendixes give additional information: a list of **bibliographic references** , a **glossary** and a list of **contact addresses**. The glossary defines the terminology used in both the descriptive environment and the technical part. This terminology is written in blue in the text. The contact appendix contains a non exhaustive list of addresses or Internet sites in the assessment, installation, sale or calibration of ecological solutions for permanent moorings.



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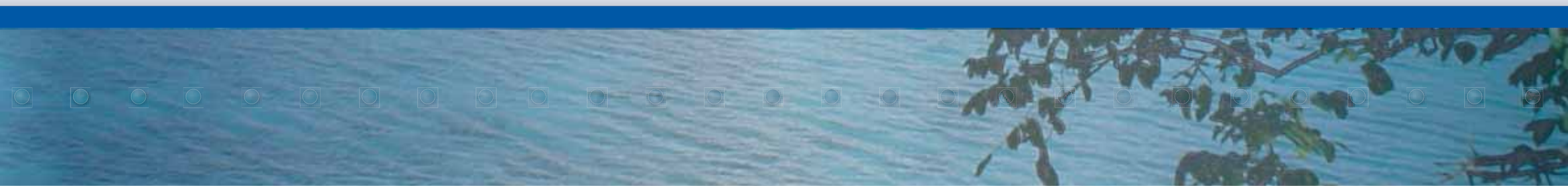


ECOLOGICAL MOORINGS

SAND AND MUD

THE ENVIRONMENT

I - Description

Using simple terms such as mud, fine sandy mud, coarse sand etc. indicates clearly that the nature of this particular environment, is one of soft substrates. Fundamentally the nature of sediments is determined by the geological structure of the watershed and the shore. The presence of fine particles (under 63 micrometers) is in relation to the muddy fraction. Above one millimeter, particles are considered as gravels or small blocks of rock (see Part 1, "Pebbles and cobbles") .

These soft substrates (sand and mud), can be seen from the shore (**supralittoral zone**) down to the great depths (**abyssal zone**). Moorings, whatever their type will happen only in areas stretching from a few meters to a maximum of 20 to 30 meters. The only zones affected are therefore the **infralittoral** and **lower sublittoral** zone .

The **infralittoral zone** starts just below the low waters of the spring tides. The shallowest zones can be covered by fine sands usually quite heterogeneous, most of the time mixed with a small fraction of dead shells and small gravel or debris from dead Posidonia leaves.

Going further down, up to 20 meters deep, sands are fine, well calibrated and usually without coarse elements because these elements are thrown ashore by the hydrodynamic energy of the sea. Going even deeper, the sea floor can be made up of various substrates (Posidonia meadows, rocks) or it can remain loose with almost no vegetal cover, but there is then a significant fraction which is either muddy or coarse.

The presence of sediments more or less muddy indicates the beginning of the **lower sublittoral** zone .

Depending on the hydrodynamism, the depth and the topography of the coast, the respective parts of sand, mud, and **organogenic debris** (shells, tests, etc.) are highly variable and characterize several **biocenoses** reaching depths of up to 90 meters.

II - Ecological benefits

The presence of soft sediments allows animals to bury easily as opposed to more compact environments (Posidonia meadows, pebbles, rocks or coralligenous bottoms).

This physical characteristic explains why, at first sight a sandy bottom looks deserted . A few flat fish can swim over it or rest on it ; some tubeworms (Mediterranean fanworm, feather-duster worm, *Lanice*) can stick out but the diversity seems generally low compared to other environments.

However, deeper in the sediment or at night, the situation is very different. These environments shelter a certain type of fauna generally small in size and with the capacity to bury itself. Within the large size species there are numerous bivalve shells (*Tellina, Venus, Donax*, etc.), annelid worms (*Nepthys, Owenia*, etc.), crustaceans (*Upogenia, Callianassa*, etc.), echinoderms (*Echinocardium*, etc.), fish (*Gobius, Callionymus, Solea*, etc.). A large number of small size species making up the **meiobenthos** and **interstitial** fauna also live in this sand and mud environment. They live most of the time buried and occupy the **interstitial** space left vacant between the grains of sand .

The ecological importance of a sand and mud environment is considerable because the animals living there are for the most part preferential prey for numerous species living in Posidona meadows, rocky environments (*Coris, Symphodus, Serranus*, etc.) or even in the same soft bottom environments (*Mullus, Solea*, etc.). It is also an area of **recruitment** for numerous fish of economical interest, small scale fishing (*Mullus* , *Solea*, etc.) or protected species of invertebrates (*Pinna nobilis*) .

Finally on these soft environments vegetal formations can develop. They are made of **phanerogams**: Zostera meadows (*Zostera noltii*) or Cymodocea meadows (*Cymodocea nodosa*). These two marine **phanerogams** are protected species: *C. nodosa* (Statutory order 19 July 1988, J.O. 9 August 1988) ; *Z. noltii* (Statutory order 9 May 1994 J.O. 26 July 1994) .

Some algae of high **natural heritage** interest can also be found in these coastal soft bottom environments: for example *Penicillus capitatus* and *Caulerpa prolifera* .
As opposed to Posidonia meadows that can also be found on sandy bottoms (see Part 1, "Posidonia meadows"), these different formations do not build three-dimensional structures and therefore stay only on a horizontal level.

The sandy or muddy areas not subjected to a strong hydrodynamism (protected bay, etc.) can also be colonized by two species of introduced Caulerpas: *Caulerpa taxifolia* and *Caulerpa racemosa*.

This vegetation might little by little cover a large area of this "open" substrate and not encounter many obstacles to its growth or be ripped out during strong swells.

III - Sensitivity and vulnerability

Physically these environments are characterized by their low mechanical holding power . They are for this reason often avoided as sites for long term moorings, except if proper precautions are taken (e.g. length of chain). These environments can also be characterized by their lack of three-dimensional structure, at least at the scale of the mooring device. At the surface these environments look flat with no asperity or **bio-construction**.

The presence of a large proportion of mud or fine particles in the sediment will create a strong suction effect "pull out resistance" on a flat surface. This physical characteristic can sometimes be used to reinforce the strength of a mooring. Whatever the mooring type is, only the surface of the sediment will be concerned and because of its architecture no (or very few) three-dimensional structures risk being destroyed. In the case of a temporary mooring or the installation of a permanent structure, the abilities for animals to bury themselves or move quickly will probably protect them from being highly affected. However, to date, no scientific study has been carried out to quantify such impacts on soft bottoms.

On the contrary some large size species with a limited ability to move can be highly vulnerable: pen shell (*Pinna nobilis*), heart urchin (*Echinocardium*), etc. The same will happen if some vegetal species (*Zostera, Cymodocea, Caulerpa, Penicillus)* are present. The impacts can therefore be significant (ripping out, destruction, covering up)

Fragments of *Caulerpa taxifolia* or *Caulerpa racemosa* developing in this environment are sometimes being lifted by anchors or chains after a mooring. If these fragments are not carefully put ashore they could colonize a new site, once the anchor is removed.

Permanent moorings have the ecological benefit of limiting the risks of dissemination with Caulerpas invading other areas through anchors and boat chains .

ADAPTED MOORING TECHNIQUES

A - Sand screw

I - Definition

A sand screw is a device made of a shaft with one or several discs in a shape of an helix or spire of an Archimedes screw.

It is well adapted to all sorts of sedimentary bottoms and has a wide range of usage : from the fastening of small marking buoys to large ships.

One advantage of this system is that it is removable, the sand screw can be unscrewed and reused on another site.

II - Model description

Built of galvanized steel, the sand screw exists in light or heavy models.

For the light models the shaft, which is the body of the screw, is made of a steel bar of 18 to 30 mm in diameter. The disc diameter can vary from 150 to 250 mm. The head of the shaft is bent to form a closed loop welded to itself.

For the heavier models, the central shaft is made of a pipe with an external diameter of at least 60 mm. The diameter of the screw part itself (coned or straight) can vary between 250 to 400 mm.

These anchoring devices can be installed individually or in a line of 2 or 3 with a coupling bar.

III - Holding principle

The pullout resistance of the buried anchor in sand is directly linked to the volume and nature of the materials of the inversed cone, situated above the inferior turn of the screw.

A suction effect also exists on the inferior side of the disc .
This resistance varies according to 3 parameters which are: the depth of the screw in the sediment , the diameter and thickness of the disc or the helix, and the mechanical resistance of the sediment.

IV -Ecological benefits

The impact of the sand screw on the sand and mud environment is extremely low. The size of the sand screw is reduced with only the head uncovered sticking out a few centimeters from the substrate.

This advantage is particularly valuable in areas subjected to currents. In this case the whole volume of sediment moved creates a hydraulic turbulence which in turn provokes a **scouring** effect. This specific effect does not happen with the use of a sand screw because the volume of the head is insignificant. The **biotope** is not modified during the installation of the anchor because there is no movement of material or mixing of the sediment. This enables us to consider that the **biocenose** is not particularly disturbed.

The implementation of the sand screw is straight forward and doesn't involve heavy equipment or techniques which could cause secondary damage. The accurate positioning of the device allows the installation to take place at a very precise site (e.g. a small patch of sand in a middle of a posidonia meadow) .

V - Installation technique

The installation of the sand screw does not require important nautical equipment. The required space and the weight of the installation equipment is not that significant and the size of the working boat involved can equally be small.

Manual screwing

This technique can be considered only with the small models of sand screws (short length) and in a substrate where the mechanical resistance is not too high. With the use of a lever bar placed in the head loop, two underwater workers facing each other turn the anchor into the ground until completion. The limits of this technique are the physical force that can be developed by the arms of the underwater workers as well as the length of the lever used. The absence of a real fulcrum in a sand and mud environment considerably reduces the development of a significant force.

Machine assisted screwing

This technique allows the development of very high **screwing torques** and if necessary to work at different depths while controlling the power applied to the system. It also avoids the underwater workers using too much physical efforts. The equipment needed is composed of a hydraulic power unit , 2 hydraulic hoses of sufficient length and a screw gun with a hydraulic engine and a head adapted to the anchor head. This screwing tool possesses two arms so that it can be handled by the workers. These workers standing on the seafloor provide an anchor point (as much as they can). Above an anchor length of 1,5 meters, some fixed anchor points will be required because the arms of the screwing system become unreachable and not easy to use.
The screwing with a hydraulic machine is by far the best installation technique.

Recommendation

The best combination of substrate and anchor device must always be found.
The conditions of use must be properly identified as well as the wind, the wave height and the volume and nature of the object (boat, pontoon, and buoy) that it will hold. The maximum wind speed and wave height will allow an estimation of the maximum force that the projected moorings will be able to resist.

The mooring needs to be completely anchored in the sediment. To release any doubt in the case of an incomplete screwing, the sand screw should be unscrewed and moved to another place to be properly set up. It is not advisable to try to help the screwing with the use of the hydro-jetting technique (high pressure water gun).

V - Choice of models

According to its use

It is the desired resistance of the mooring that determines the choice of a model. A general rule is that the resistance is proportional to the diameter of the disc and the total length of the anchor. Whether the direction of the effort on the anchor is consistent or not, is also an important criteria in the choice of the device. If the direction is known and consistent (e.g. mooring of a fixed pontoon or a marking buoy in a strain type mooring) it is necessary to screw the anchor in the same axis so that the effort applied is applied only in an axial direction on the shaft of the screw. In all these cases model 1 can be used, it is just necessary to adapt the diameter of the disc and the total length of the shaft.

If the direction of the load applied to the anchor changes in direction and angle (e.g. swinging mooring of a boat with variations due to the wind and the swell), it is necessary to screw the anchor vertically into the sea floor. In this type of situation the shaft of the anchor will be affected by lateral/ horizontal stress created by the boat's mooring lines.

In all these situations, the second and third model are suitable. The shaft made of a tube will be able to resist much more to being deflected laterally than a thinner steel bar of 20 to 30 mm in diameter. The length of the shaft and the diameter of the discs must be adapted to the estimated load.

According to the quality of the substrate

The mechanical resistance of the sea floor is the major issue in the choice of the anchor size. It is not necessary to accurately calculate this resistance, as done by soil mechanic specialists with tools such a **penetrometer** or **vane tester,** but rather to evaluate and estimate it.

It is necessary to check the available thickness of the sediment in relation to the minimum length of the anchor to be installed. With an identical load on different substrates, the more fluent , soft and muddy, and of low **compaction** the sediment is, the more the anchor will need to be long and with a large disc diameter or even better with discs on two levels.

The shaft also will need to be very rigid if a horizontal stress is applied (model 3) or with a solid shaft (model 1) if the stress is only axial.

The more the soil is compact, dense, with fine particles, and not sensitive to **scouring** by hydraulic effects, the more the anchor will need to be of «normal proportions». This means a medium length and disc diameter but with a very rigid shaft resistant to the **torque** applied at the installation.

According to the estimated load

Standard sizes of sand screws varies between 0.80 m to 3 m. Above this size the technique used for installation is heavier and requires larger boats.

The whole implementation can have a significant impact on the environment (moving of large boats, repeated anchoring, repositioning). It is therefore more advantageous to increase the number of screws in order to divide the load, than to put in place one large anchor.

Triple sand screw on a sand and mud environment.

An anchoring device can be made up of one or several screws (2 or 3) attached together with a coupling bar (model 4).

It is equally possible to hookup together for example two sets of triple sand screws. In this case the traction load is shared out between six anchors.

Model 1

Model 2

Model 3

Model 4

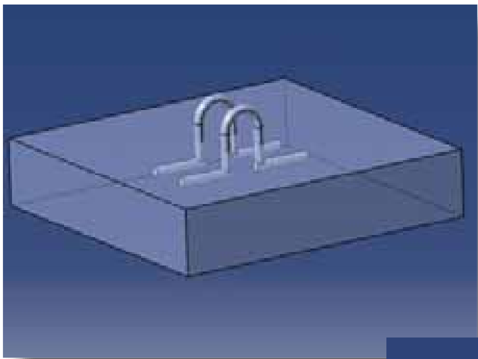
B - Deadweight mooring

I - Definition

The deadweight mooring is an object with a high density sunk onto the sea floor to provide a permanent anchor. It is well adapted to sandy bottoms and compact sediments and also has a wide range of usage: from the mooring of small marking buoys to the mooring of large vessels.

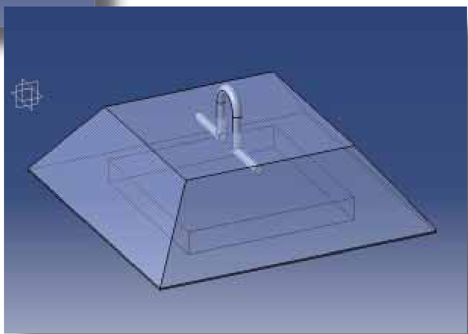
II - Model description

In general a classic deadweight mooring has a square shape; its height is equal to 1/5 or ¼ of its length. The material often used for practical reasons is concrete, with sea-worthy qualities if possible.
Internal metal work is highly recommended as it provides a better mechanical resistance and increases the density of the structure.
The central **anchor-ring** is made up of a steel bar with a large diameter, for example in the shape of an omega and attached inside to the metal work. Certain deadweight moorings have on their underside a cavity that increases its suction effect. Others can have a polyedric shape (a base of a square pyramid) which improves its stability and limits the possibility of overturning .



III - Holding principle

The pull-out resistance of a dead weight mooring is linked to two principle factors: its apparent weight (dry weight minus the Archimedes force) and the size of the surface in contact with the seabed.



IV -Ecological benefits

The deadweight can be considered as a technical solution acceptable on sandy substrate on condition that, the volume of the material used in this environment does not have any secondary impact other than its own presence.

Nevertheless some disadvantages of this type of mooring are: the permanent occupation of the seabed surface and the risk of sliding and ripping because of a too heavy load or a bad estimation of the mooring line.

For areas affected by currents, the volume of the dead-weight mooring above the surface of the sea floor generates hydraulic turbulences and causes a **scouring** effect.

V - Installation technique

The installation process is done in several phases:

•Land transportation of the deadweight mooring.

•Handling in order to load it onto a barge or a working boat, or placing it in the water to be towed when the deadweight mooring has a floatability chamber.

•Maritime transportation.

•Immersion of the mooring and placing it safely on the sea bed in the allotted place.

The resources used should be proportional to the weight of the mooring to be put in place.

Small deadweight moorings
For small deadweight moorings, all handling can be manual or assisted by a handling boom, a small winch or a hoist. The descent to the bottom can be simply controlled with its own mooring line or any other line properly secured and controlled by a cleat or a bollard.

Medium and large moorings
For medium and large moorings, all the handling is more tricky and requires professional intervention (land based lifting crane, hydraulic crane on a boat, management of the moving weight on the boat).

The descent to the bottom is generally done with the help of a winch at the end of the arm-crane on the boat. Properly adapted boats and equipment are always a safety precautions. There exists other ways such as, floating chambers catamaran style with a handling boom and a winch and small barge with a central hole and winch.

The use of a lift bag (large soft bag filled with air) is possible but reserved to highly trained and experienced personal. The uncontrolled variations in the air in the lift bag and potential leaks can be very dangerous. It is not considered to be a good idea to directly release the deadweight mooring from the surface with its complete mooring line. In these conditions the deadweight does not descend vertically, the speed of the descent on its underside creates a lift and therefore its trajectory is skew and random. The landing on the seabed is uncontrolled and very imprecise and the deadweight mooring can completely overturn trapping its mooring line. For a large size deadweight mooring, installed in deep places, it is indispensable to use a specialized boat.

Recommendations

The dead weight should include a second **anchor ring** that will be used when the first is worn out (the replacing of an **anchor ring** on a deadweight mooring already in place is an expensive and difficult operation).

The section of the **anchor ring** must be oversized as it is the only wearable part. The use of a mobile **anchor ring** (e.g. a few chain links attached to the concrete) must be avoided, as the movement of the links means that permanent wearing will take place.

The conditions of use must be properly identified as well as the wind, the wave height and the volume and nature of the object (boat, pontoon, and buoy) that it will hold. The maximum wind speed and wave height will allow an estimation of the maximum force that the projected moorings will be able to resist.

The shape and weight must therefore be adapted to the load expected. Finally the cost of handling and transportation must be taken into account when looking at the option of a deadweight mooring.

V - Choice of models

According to use

This choice is relatively simple aside from the calculation of the sliding coefficient done by soil specialists. It is the apparent weight and the shape which will influence the choice. As with all types of anchorage, the deadweight will be subjected to an important stress.

When in a situation where the stress is mainly vertical and the floating objects on the surface may be submerged (marking buoys anchored with a tight or short mooring line to limit the swinging space); a flat shape is not essential, but the apparent weight of the deadweight should be superior to the Archimedes force provoked by the total immersion of the object attached on the surface.

The shape of the concrete block will be very important due to the fact that, in the majority of cases the stress is horizontal and is applied by a structure through a long line. The largest surface possible is then preferable. Its apparent weight will be proportional to the force created by the attached floating object.

According to the quality of the substrate

Fine sediment, dense and slightly muddy will clearly improve the suction effect of the deadweight and increase its hold. The same block submitted to the same force with a coarse shell or madrepore sand will slide more easily.
On a softer muddy-sand the hold will be of poor quality, the deadweight will be moved easily in a lateral way and will bury itself until it finds a substrate sufficiently dense to hold it properly.

According to the estimated load

As opposed to other techniques of mooring, the deadweight mooring is the only one that is placed on the sea floor. If its dimensions are incorrect, it will move in the direction of the dynamic force.
This often happens when some significant swell makes the working angle of the mooring line vary greatly.

The traditional deadweight mooring is made of a block of a certain weight and a simple mooring line. This simple mooring line is made of a few meters of ground mooring chain of large diameter, plus a longer mooring chain of a smaller diameter then linked to a rope made of technical textile. This classic method gives an overall good resistance. The various elements of the system enable the absorption of the load. In the case of a small force, only the mooring chain is under tension. However if the force is greater, the mooring chain as well as the length of the ground-mooring chain, is under stress. With a very important force, the two chains absorb a large part of the force while the weight of the deadweight absorbs the residual effort.

This traditional conception of a mooring line is today banned because of its destructive impact on the environment due to the incessant sweeping of the chain on the sea floor. In Part 3, intermediary and surface elements, we will detail techniques for having mooring lines that are more environmentally respectful.

If we take away the absorbing effect of the chains, the weight of the deadweight must be increased and the correct working angle of the mooring line must be respected.
The **trenching** of the deadweight (to bury the deadweight in a hole of identical depth to the height of the concrete block) increases the resistance and avoids the effect of **scouring** and keeps the draught identical (height of water above the sea bottom).

The installation is longer and more costly, the equipment required (hydrolift, hydro-jetting, etc.) is heavier, and the moving of the substrate material and the resuspension of the fine sediment has a negative impact on the living environment.

SOLUTIONS AND ESTIMATED COST

- L= length in mm - TØ = shaft diametrer in mm - DØ = disc diameter in mm - PR = Dry weight in tons - FSS = sub-surface float, diameter in mm - BRCC = rigid buoy with central chimney	- Estimated cost of supplies in euros (without tax and delivery cost) - All dimensions in mm - Floating line: rope linking marking buoys together and fastened to these - Floating structure : a swimming platform of 4 x 4 m on a swinging mooring

SAND SCREW

LIGHTWEIGHT BOATS < 7 METERS Screw: L 1500, TØ 20/30, DØ 250 Polyamide line Ø 18, buoy FSS 11 litres + BRCC Cost anchor only: 60 e
MEDIUM WEIGHT BOATS 7 TO 11 METERS Screw: L 1500/1800, TØ 60, DØ 300 Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: 400 e
HEAVYWEIGHT BOATS 12 TO 18 METERS Screw: L 2000, TØ 60, DØ 350 Single screw, double or triple depending on size and weather conditions Polyamide line Ø 24/30, buoy FSS 11/25 litres ,BRCC 650 Cost anchor only: Simple 500 e, double 1200 e, triple 1500 e
MARKING BUOYS Buoy 400/600 : Screw: L 800/1000/1500, TØ 16/18/20, DØ 200/250 Buoy 800 : Screw: L 1500, TØ20, DØ 200/250 Polyamide line Ø 14/16, chain 12-16 Buoy FSS 6/8 litres Cost anchor only: 30 to 60 e
FLOATING LINE Screw: L 1500, TØ20, DØ 250 Polyamide line Ø 14/16 , chain Ø 12 / 16 Buoy FSS 6/8 litres Estimated cost anchor only: 60 e
FLOATING STRUCTURE Screw: L 1500/2000, TØ 60, DØ 350 Polyamide line Ø 24, FSS 11 litres, swivel Ø 20 chain in mid-water Ø 20 Estimated cost anchor only: 500 e
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

DEAD WEIGHT

LIGHTWEIGHT BOATS < 7 METERS PR= 0,8 to 1,5 t Polyamide line Ø 18 , buoy FSS 11 litres + BRCC Cost anchor only: 100 to 250 e
MEDIUM WEIGHT BOATS 7 TO 11 METERS PR= 2 to 3,5 t Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: 450 e
HEAVYWEIGHT BOATS 12 TO 18 METERS PR= 4 to 6 t Polyamide line Ø 24/30, buoy FSS 11/50 litres ,BRCC 650 Cost anchor only: 550 to 800 e
MARKING BUOYS Buoy 400/600 : PR= 0,12 t to 0,25 t Buoy 800 : PR= 0,40 t Polyamide line Ø 14/16, chain 12-16 Buoy FSS 6-8 litres Cost anchor only: 60 to 100 e
FLOATING LINE PR = 0.4 t Polyamide line Ø 14/16, chain 12 / 16 Estimated cost anchor only: 100 e
FLOATING STRUCTURE PR = 2.5 t Polyamide line Ø 24, Buoy FSS 11 litres , swivel Ø 20, chain in mid-water Ø 20 Estimated cost anchor only: 400 e
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

ECOLOGICAL MOORINGS

ON PEBBLES AND COBBLES

THE ENVIRONMENT

I - Description

Intermediary between the soft and hard substrate, the areas of pebbles and cobbles are characterized by the presence of mobile elements of a variable size (several centimeters to several decimeters in diameter) resting in layers of different thickness.

In the coves of rocky coasts more or less exposed to waves, areas of pebbles are often seen. The average diameter of these pebbles doesn't exceed tens of centimeters in diameter. Above this size we talk of small blocks of rock, crushed rock or cobbles.

In calmer areas, with a lower hydrodynamism, the continuous sedimentation of finer particles helps to turn the environment into a sandier zone.

These areas of pebbles are strongly linked to the hydrodynamism of the site. Because the hydrodynamic energy quickly reduces at higher depths, such areas are rarely seen below a depth of a few meters. It is possible to see cobbles at only a few meters from the surface and up to 50 meters or more.

The elements composing these zones are more or less mobile in accordance to their size. When their size becomes too significant (a meter or more in diameter), the term cobbles becomes inappropriate and it is better to talk of boulders or blocks.

If pebbles can be seen only on flat bottoms, the cobble zones can affect areas with quiet steep slopes. The instability of these bottoms will be greater when the slope is more significant.

Depending on the regularity of the size of the elements making up a floor of pebbles or cobbles, the space between these elements will be very different. The space will be greatly reduced

II - Ecological importance

These environments as previously described, are characteristically unstable. This instability strongly limits or totally prevents the installation of **sessile** organisms at the surface of the pebbles or small rocks.

Sessile fauna or flora will only be seen in the presence of elements of large size, stable or not very mobile.

In the case where neither sand nor fine gravel can clog up the **interstices** between the pebbles, the ecosystem is very simple: organic debris brought by the sea and stuck in the **interstices** feed two **detritivorous** amphipod crustaceans (*Melita hergensis* and *Allochestes aquilinus*). These can be prey for a Gobiescidae (*Gouania wildenowii*).

While the size of the cobbles increases, the instability decreases and the density of the flora and fauna increases.

However large fixed species present on the rocks (see part 1, "Boulders and bedrock") are absent. Most of the **specific diversity** is represented by small mobile species living in the **interstices** or fixed under the elements. Nevertheless the diversity is far from reaching the one present in fields of large blocks.

Taking into account what has been mentioned, the ecological importance of these environments is certainly more limited than others (coralligenous formations, **phanerogam** meadows, etc.).

However certain species are strictly confined to these environments and for this reason, they are considered very rare. The small *Gouania wildenowii* is a typical example

III - Sensitivity and vulnerability

These environments are characterized by their considerable mechanical instability. As a result they are often avoided for long term moorings unless proper precautions are taken (e.g. significant length of chain, etc.).

Whatever the average size of the elements that make up the bottom, they are a problem when mooring.

On pebble floors, the instability is so high that it is a risky operation to moor using an anchor, in particular for boats when they are unable to wedge the anchor into the substrate. For this reason these substrates are often avoided by leisure boats.

It is actually very difficult to estimate the vulnerability of such environments. In comparison with other environments, the **specific diversity** is limited and the ecological interest is certainly less.

The act of mooring will create a movement of elements by displacing or overturning the elements.

As the majority of living species in this environment are adapted to the mobility or instability of the substrate, the impact can be very slight.

If the rubble bottom is made up of elements of a significant size, some of the species can live attached to the underside of the small elements.

The presence of living organisms on the underside illustrates the sciaphil characteristic of the organisms. Any turning-over of these elements thus causes the deaths of the organisms.

ADAPTED MOORING TECHNIQUES

A - Sand screw (see also sand screw in Part 1, Sand and mud)

I - Definition

The sand screw adapted to pebbles and cobbles correspond to models 2, 3 and 4 (see also sand screw in Part 1, Sand and mud)

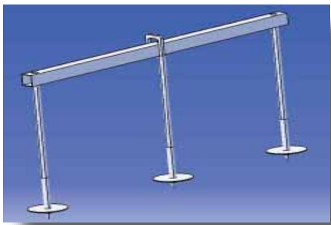
Model 2

Model 3

II - Model description

The adapted models are only the heavy duty ones with a central shaft made up of a tube with an external diameter of 60 mm or more.
The diameter of the spires can vary from 250 to 400 mm. The total length varies between 1 to 2 meters. The helix is cone-shaped (see model 2). The small size of the cutting edge allows the screw to move between the pebbles more easily.
The pitch of the screw (distance between two sides of the spire during a complete turn) will always be superior to the maximum diameter of the biggest pebbles present at the site.

This mooring can be installed individually or attached in lines of 2 or 3 with a coupling bar.



Model 4 : Sand screws with a coupling bar

III - Holding principle

The pull-out resistance will be satisfactory to very good if the following conditions are met: stability of the pebble area and the presence of sand and fine gravel giving a good cohesion for the layer of substrate affected.

IV -Ecological benefits

As the ecological interest of the environment is less than that of the other environments, the ecological value of the sand screw is fairly limited.

V - Installation techniques

The use of a hydraulic power unit is required. The installation will also be helped by the use of a stabilizing frame giving an anchor point to the screw gun . This frame will absorb blows when the screw is being dug into the pebbles.

The size of the pebbles and small cobbles will have to be estimated as well as the presence of sand or small gravel. If the pebbles have a diameter over 10 cm and if the cobbles are large and mixed together with absence of sand and gravel, the device will not screw into the substrate. Another technique will have to be used (see other techniques in Part 1, Pebbles and cobbles").
If the ground is made of pebbles, sparse cobbles and sand then the best combination of sand screw model and the substrate will need to be looked for.
The conditions of use for the permanent mooring need to be defined and limits chosen (in connection to wave height and wind speed) in the size and weight of the objects moored to the permanent mooring. Wind speed and wave height allows the calculation of the maximum load that will have to be faced by the system (including intermediary elements). The shaft must be entirely screwed into the substrate and if the screwing is incomplete the equipment needs to be removed to satisfactorily install it at another location. It is difficult with this type of substrate to easily evaluate the thickness available and the consistency of its composition.

B - Dead weight mooring: see also Dead weight in Part 1, Sand and mud

I - Characteristics

The deadweight mooring is a technique adapted to pebbles and cobbles.

The mechanical characteristics of this ground, compared to a sandy or muddy ground, change the pull out resistance of a dead weight.

In the presence of pebbles and cobbles, the suction effect no longer exists; the underside of the concrete block lays only on a reduced number of contact points.

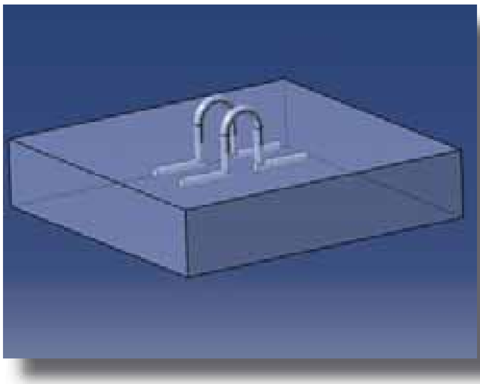
The contact area is proportionally low and the soil is relatively unstable and the round shape of the pebbles promotes the sliding effect.

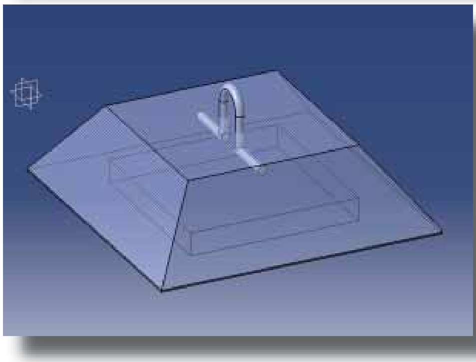
II - Description

With the same conditions of use, the models for pebbles and cobbles have to be heavier than those for softer substrates to compensate for the sliding effect.

A positive advantage can be obtained if there is a cavity on the underside of the deadweight.

The deadweight will settle better on the seafloor, coping with irregularities of the surface and of the protruding cobbles.





III - Ecological benefits

As the ecological interest of the environment is less than for most of the other environments, the ecological value of the deadweight is fairly limited.

IV - Technical principle

The pullout resistance is closely linked to the apparent weight.

V - Installation techniques

In case of an irregular floor of cobbles, the precise location of the deadweight will need to be chosen. This needs to be where the concrete block lays the best and would itself be blocked by bigger and sticking out cobbles. If necessary prepare the place by moving certain cobbles.

In the presence of pebbles, it is better to prepare the zone to get a uniform support and a good trim for the deadweight. Partial **trenching** of the deadweight into the substrate will improve the pullout resistance.

Recommendations
The dead weight should include a second **anchor ring** that will be used when the first is worn out (the replacing of an **anchor ring** on a deadweight mooring already in place is an expensive and difficult operation).

The section of the **anchor ring** must be oversized as it is the only wearable part. The use of a mobile **anchor ring** (e.g. a few chain links attached to the concrete) must be avoided as movements of the links create a permanent wearing effect.

The conditions of use must be properly identified as well as the wind, the wave height and the volume and nature of the object (boat, pontoon and buoy) that it will hold. The maximum wind speed and wave height will allow an estimation of the maximum force that the projected moorings will be able to resist. The shape and weight must therefore be adapted to the load expected.

Finally the cost of handling and transportation must be taken into account when looking at the option of a deadweight mooring

SOLUTIONS AND ESTIMATED COST

- L= length in mm - TØ = shaft diametrer in mm - DØ = disc diameter in mm - PR = Dry weight in tons - FSS = sub-surface float, diameter in mm - BRCC = rigid buoy with central chimney	- Estimated cost of supplies in euros (without tax and delivery cost) - All dimensions in mm - Floating line: rope linking marking buoys together and fastened to these - Floating structure : a swimming platform of 4 x 4 m on a swinging mooring

SAND SCREW

LIGHTWEIGHT BOATS < 7 METERS Screw: L 1500, TØ 60, DØ 250/300 Polyamide line Ø 18, buoy FSS 11 litres + BRCC Cost anchor only: 400 v
MEDIUM WEIGHT BOATS 7 TO 11 METERS Screw: L 1500/2000, TØ 60, DØ 300 Single screw or double Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: simple 500 g, double 1200 e
HEAVYWEIGHT BOATS 12 TO 18 METERS Screw: L 2000, TØ 60, DØ 350 Screw double or triple depending on size and weather conditions Polyamide line Ø 24/30, buoy FSS 11/25 litres ,BRCC 650 Cost anchor only: double 1200 v, triple 1500 v
MARKING BUOYS Buoy 400/600 , Screw: L 800/1000/1500, TØ 16/18/20, DØ 200/250 Buoy 800, Screw: L 1500, TØ20, DØ 200/250 Polyamide line Ø 14/16, chain 12-16 Buoy FSS 6/8 litres Cost anchor only: 30 to 60 g
FLOATING LINE Screw: L 1500, TØ20, DØ 250 Polyamide line Ø 14/16 , chain Ø 12 / 16 Buoy FSS 6/8 litres Estimated cost anchor only: 60 v
FLOATING STRUCTURE Screw: L 1500/2000, TØ 60, DØ 350 Polyamide line Ø 24, buoy FSS 11 litres, swivel 20 chain in mid-water 20 Estimated cost anchor only: 500 g
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

DEAD WEIGHT

LIGHTWEIGHT BOATS < 7 METERS PR= 0,8 to 1,5 t Polyamide line Ø 18 , buoy FSS 11 litres + BRCC Cost anchor only: 100 to 250 v
MEDIUM WEIGHT BOATS 7 TO 11 METERS PR= 2 to 3,5 t Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: 450 g
HEAVYWEIGHT BOATS 12 TO 18 METERS PR= 4 to 6 t Polyamide line Ø 24/30, buoy FSS 11/50 litres ,BRCC 650 Cost anchor only: 550 to 800 v
MARKING BUOYS Buoy 400/600 : PR= 0,12 t to 0,25 t Buoy 800 : PR= 0,4 t Polyamide line Ø 14/16, chain 12-16 Buoy FSS 6-8 litres Cost anchor only: 60 to 100 g
FLOATING LINE PR = 0.4 t Polyamide line Ø 14/16 , chain Ø 12 / 16 Estimated cost anchor only: 100 v
FLOATING STRUCTURE PR = 2.5 t Polyamide line Ø 24, Buoy FSS 11 litres , swivel 20, chain in mid-water 20 Estimated cost anchor only: 400 g
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

ECOLOGICAL MOORINGS

ON BOULDERS AND BEDROCK

THE ENVIRONMENT

I - Description

Areas of boulders and bedrock are definitely part of the hard substrate category. Made of blocks of large size (from a few decimeters to several meters in diameter) or continuous bedrock, these seafloors are characterized by the immobility of the elements they are made up of.

These areas of boulders and bedrock can be seen from the surface along rocky coasts down to high depths.

If the **biocenoses** of **supralittoral** or **mediolittoral** are not much affected by anchorages due to their closeness to the surface, this is not the case in deeper areas for the **biocenoses** of photophil algae that make up most of this environment. The description of this environment will thus focus mainly on this **biocenose**.

The stability of the elements that make up this environment allows the development of a dense fixed flora and fauna at the surface of the boulders or of the bedrock.

The presence of boulders will mean the presence of numerous spaces in between them. In contrast to a bedrock substrate, the number of cavities will be very reduced or inexistent. These microhabitats (cavities or spaces between the boulders) can be colonized by a **vagile** or **sessile** fauna, usually **sciaphilic**.

The absence of cavities therefore reduces **specific richness**. Other physical factors such as the quantity of light and hydrodynamism will equally have an impact on the richness of this environment. A strong hydrodynamism will reduce the abundance of large size **sessile** animal species while the vegetation (Cystoseira algae) will still be present.

Excepted for rocky environments made of large flat rocks, the boulders and bedrock environments are fairly heterogeneous and often home to a mosaic of habitats. The habitats are usually organized in layers from **sciaphilic** (cavities) to **photophilic** (upper side of boulders and bedrock) zones.

Hard substrates populations are dominated qualitatively and quantitatively by the vegetation in the **infralittoral** (and to a smaller degree **lower sublittoral)** zones.

Bio-constructions can develop on rocks (boulders or bedrock), like the calcareous horizontal structures built by the Lithophyllum or the coralligenous but they will not be described here. The Lithophyllum "pavements" or "sidewalks" are too high to be concerned

II - Ecological importance

The **biocenose** of the **photophilic** algae occupy mainly areas of boulders and bedrock. This **biocenose** of high richness regroups several algal communities. At depths animal species (gorgons, *Eunicella*) can also occur in these environments.

The **specific richness** of this **biocenose** is reinforced by the level of heterogeneity and the number of layers present. Very often, several hundreds of species can be seen in this environment with always the main groups being algae, polychaetes, mollusks, and crustaceans.

The **production** is high and the **food webs** are complex but open to other hard and soft substrate **biotopes** through exportation of organic material (preys, waste,etc). Aside from Posidonia meadows (see "Posidonia meadows") these environments have the highest **production** rate of the Mediterranean.

This great ecological importance is reinforced by the role of being **nurseries** to several species of fish of high economical interest or **natural heritage** value: seabream (*Diplodus*), comber (*Serranus*), dusky grouper (*Epinephelus marginatus*) and brown meager (*Sciaena umbra*).

Depending on the species, the juveniles will seek refuge in Cystoseira forests (combers and wrasses) or in the cavities between the boulders (brown meager, dusky grouper). Several other species of fish frequent this environment when in the juvenile stage (*Symphodus roissali*) or at the adult stage (several gobies some of which are very rare or inexistent outside this habitat).

III - Sensitivity and vulnerability

These environments are part of the hard substrate category. The major obstacle to moorings would be the hardness of the substrate. The heterogeneity of the substrate (cavities for bedrock areas or spaces between the boulders) reinforce the problems presented by anchoring in these environments (high risk of having the anchor stuck).

On the contrary the size of the blocks is such that it makes the environment stable in comparison to pebbles and cobbles. The ability for the anchor to hook onto something will therefore be very likely.

As opposed to boulders and bedrock cavities, a large area of flat rock can cause difficulties when anchoring because of the absence of infractuosity for an anchor to hook onto. It is certain taking into account the great ecological importance of this environment that the impact of unadapted moorings can be very significant. In fact, the development of algal communities of large size species (several decimeters for Cystoseira forests) represents a major factor of vulnerability.

If an anchor does not modify the three-dimensional structure because of the stability the elements, it still can erode the algae forest. These environments shelter a fauna of high diversity which is a source for food for others species living in the **interstices** or the cavities.

Any reduction in the surface of algae, especially macro algae brings with it considerable reduction of **specific richness** similar to a pollution accident. The significant reduction of the **production** can then have indirect repercussion on the adjacent environments supplied with organic matter from these areas.

ADAPTED MOORING TECHNIQUES

Grouted anchor

I - Definition

A grouted anchor is a system made of a plate or a single **anchor ring** with one or many threaded rods, or ringbolts resin-bonded into the rock with an underwater injected grout.

It is well adapted to homogeneous rocky substrates and has a wide range of use: from the anchoring of small marking buoys to large floating or immersed structures.

This anchoring system is not reversible and the parts used are not reusable.

II - Model description

The plate and bolts are made of heated galvanized steel or in A4 quality stainless steel. Depending on the use and the eligible load, light or heavy duty models can be designed.

For example, for light loads, a rod or a ringbolt of adapted length and diameter with an **anchor ring** can clearly be a sufficient anchor point.

Heavier and stronger models can be made of a reinforced plate with a multi directional structural resistance and fastened to the rock with several bolts of appropriate size.

The illustrations shown are just there for examples.

III -Holding principle

As for any grouted anchor the resistance of the anchor point takes into account the internal resistance of each of its components:

- anchor parts (quality of the material and the welds),
- grouting material , substrate (mechanical resistance of the rock)

IV - Ecological benefits

The impact of a grouted anchor on a boulder or the bedrock can be considered negligible. The holes in the rock for fastening one or many bolts do not create particular disturbances.

The injected grout used in very small quantities and very locally can not have a significant negative impact.

The required space is very small; the surface area for a standard plate is only 0.15 m².

The installation is simple and does not require heavy equipments or techniques that might create indirect negative effects. The positioning is very precise and allows the choice of the most adapted location.

V - Installation technique

The installation of anchors grouted in the rock requires the use of equipment of a limited size. The space required and the weight of the parts is negligible. The space required and weight of the installation equipment is minimal. The size of the boat can therefore stay small.

The installation has several phases:

1) Final choice of the most appropriate location and basic preparation of the surface if necessary of the chosen rock.

2) Drilling of the rock to the required diameter and length with an underwater drilling gun either pneumatic or hydraulic.
A pneumatic system requires an air compressor with a high rate of flow and can only work at shallow depths because of loss of pressure at depths: 1 bar per 10 meters of waters.
The hydraulic gun is preferable, it allows consistent work at any depth and the space required for a hydraulic power unit

is much smaller than with a pneumatic system. In addition the hydraulic gun reduces the physical effort needed (the weight of the gun improves the drilling) and the absence of pneumatic air exhaust preserves the eardrums of the diver.
Aside from the drill gun, the rest of the required equipment is a hydraulic power unit and 2 hydraulic hoses of appropriate length.

3) Bonding the anchor.
After cleaning the hole with pressured air, injection of the underwater grout (supplied in cartridges)

4) Immediately afterward carefully insert one or many rods into the holes filled with resin. Remove the extra resin if necessary. Wait the advised time as written on the instructions manual, without moving the parts during the hardening time.

5) The grouted anchor is ready to use. The rest of the elements can then be installed (e.g. install and tighten a plate)

Recommendations
Always look for the best adapted anchor for the substrate.

The conditions of use of a permanent mooring will have to be defined and limits will be chosen in relation to the wave height, wind speed and size and weight of the objects moored
Measuring the . wind and wave allows the calculation of the maximum load that will to be placed onto the system (including intermediary elements).
Time has to be taken to assess the nature and the quality of the rocky substrate chosen. It is not always easy to identify the presence of cracks and faults. They are often hidden by alga or coralligenous.

In order to avoid the problems created by electrolysis reactions it is recommended to make the equipment out of materials of the same quality.

The proximity of different materials such as standard steel, stainless steel, aluminum, copper, bronze and other alloys must at all costs be avoided. This rule must also be applied to the metallic parts that can be present in the mooring line, or attached to the anchor (shackles, eyes etc.).

Concerning the choice of the parts to be grouted, it is a good security measure to obtain elements well adapted to this use from a supplier of lifting equipments. The parts supplied will carry information of maximum load use in kilo grams, tons or daN . The security coefficient when lifting is 5.

VI - Choice of models

A/ According to its use
Being well adapted to its use is essential. If the anchor receives, for example, a mooring line, **anchor ring** will have an interior diameter adapted to the size of the chosen shackle.
If the anchor is designed to frequently receive a line passed quickly through by a diver, the **anchor ring** will have a very different shape. Not necessarily circular, but with a large diameter to facilitate the quick release, of the line.
If the direction of the applied load is known and constant, the drilling direction will have to be adjusted so that the bonded parts work more by shearing than in axial pulling. If the direction of the load is variable in both direction and angle, an anchor able to uniformly resist multi directional forces must be used .

B/ According to the quality of the substrates

The substrate is the most important element and it is the most difficulty to accurately assess.
The rock at the chosen location must be homogeneous and with no sign of cracks or faults. The vibrations of the drilling gun can actually weaken a part of rock which is already weak. The speed at which the drilling progresses is an indication of the hardness and the quality of the rock.
The smoothness and uniformity of the sides of the hole is also a good sign of the resistance of the rock. In a rock of lower resistance the drilling depth will be significantly deeper.
In the case of grouting an anchor on an isolated boulder, the boulder will be transformed into a natural deadweight mooring. It is necessary to be sure of the boulder's stability, its supporting points and its apparent weight.

C/ According to the estimated load

The dimensions and design of the anchor part must take into account the value of the estimated load.
The dynamic forces that are short and often violent (e.g. the backwash effect) must also be taken into account.
The diameters and thickness of the parts will need to increase proportionally with the increase of the load. The more the load increases the longer and more spaced the screws will have to be.

SOLUTIONS AND ESTIMATED COST

- L= length in mm - TØ =rod diametre in mm - FSS = sub-surface float, diameter in mm - BRCC = rigid buoy with central chimney	- Estimated cost of supplies in euros (without tax and delivery cost). - All dimensions in mm - Floating line: rope linking marking buoys together and fastened to these - Floating structure : a swimming platform of 4 x 4 m on a swinging mooring

GROUTED ANCHOR

LIGHTWEIGHT BOATS < 7 METERS Ringbolt L 250, TØ 20, Polyamide line Ø 18 , buoy FSS 11 litres + BRCC Cost anchor only: 50 e
MEDIUM WEIGHT BOATS 7 TO 11 METERS Either Ringbolt L 250, TØ 20, either small plate with 2 bolts 250 X 20 Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: ringbolt 50 e, plate 550 e
HEAVYWEIGHT BOATS 12 TO 18 METERS Plate with 2 or 4 bolts L 250/300, TØ 20/24, depending on the rock type Polyamide line Ø 24/30, buoy FSS 11/25 litres , BRCC 650 Cost anchor only: 550 to 650 e
MARKING BUOYS Buoy 400/600/800 Ringbolt L 200 TØ 16/20 Polyamide line Ø 14/16, Chain 12-16, Buoy FSS 6/8 litres Cost anchor only: 35 to 50 e
FLOATING LINE Ringbolt L 250, TØ 20 Polyamide line Ø 14/16 , chain Ø 12 / 16 mooring buoy FSS 6/8 litres Estimated cost anchor only: 50 e
FLOATING STRUCTURE Either ringbolt : L 250, TØ 20, either small plate with 2 bolts 250 X 20 Polyamide line Ø 24, buoy FSS 11 litres, swivel 20 Chain in mid-water 20 Estimated cost anchor only: 50 to 550 e
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

ECOLOGICAL MOORINGS

ON CORALLIGENOUS FORMATIONS

THE ENVIRONNEMENT

I - Description

Rocky bottoms of the Mediterranean sea have a biological **natural heritage** of great value, creating renowned underwater landscapes. This resource is coralligenous formations and is being more and more exploited for commercial use such as diving tourism.

The rocky bottoms of the **lower sublittoral** zone have several levels, one of them is the so called 'coralligenous formations' or 'coraligenous assemblages' in the broader meaning of the word, with coralligenous walls, coralligenous concretions, semi shaded cavities, hangovers and totally shaded cavities or caves.
Because of their location, the cavities are not generally affected by anchors.
Coralligenous concretions can reach a thickness of several meters. While the construction takes place on a rocky base, the aggregation of smaller concretions can also develop on a soft substrate.

The main constructing agents are the calcareous red algae Corallinacea or Peyssonneliacea. These algal concretions cans be reinforced by secondary building agents; **sciaphilic** invertebrates with calcareous tests or skeletons (Foraminifera, Madrepora, Bryozoans, Mollusks, red tube worms)

The spatial distribution of coralligenous populations is the result of a combination of factors: light, hydrology, sedimentation, and biological interactions.

Coralligenous communities on vertical walls, refered to as coralligenous walls, are vertical rocks where the calcareous algae which make up the coralligenous, are limited in their horizontal growth mainly due to the slope of the bedrock. In areas of more gentle slopes, the thickness of the concretions can become significant, and real reefs are built.

At low depths, coralligenous formations in its general meaning can be preceded by pre-coralligenous transitory populations' assemblages with the more **photophilic infralittoral** populations

The species present on coralligenous walls are mainly large **sessile** invertebrates with a protruding shape: gorgons (*Paramuricia, Eunicella*) , all the cnidarians colonies (*Geradia*) large Bryozoans (*Adeonella, Myrapora, Pentapora*) or sponges (*Axinella*)

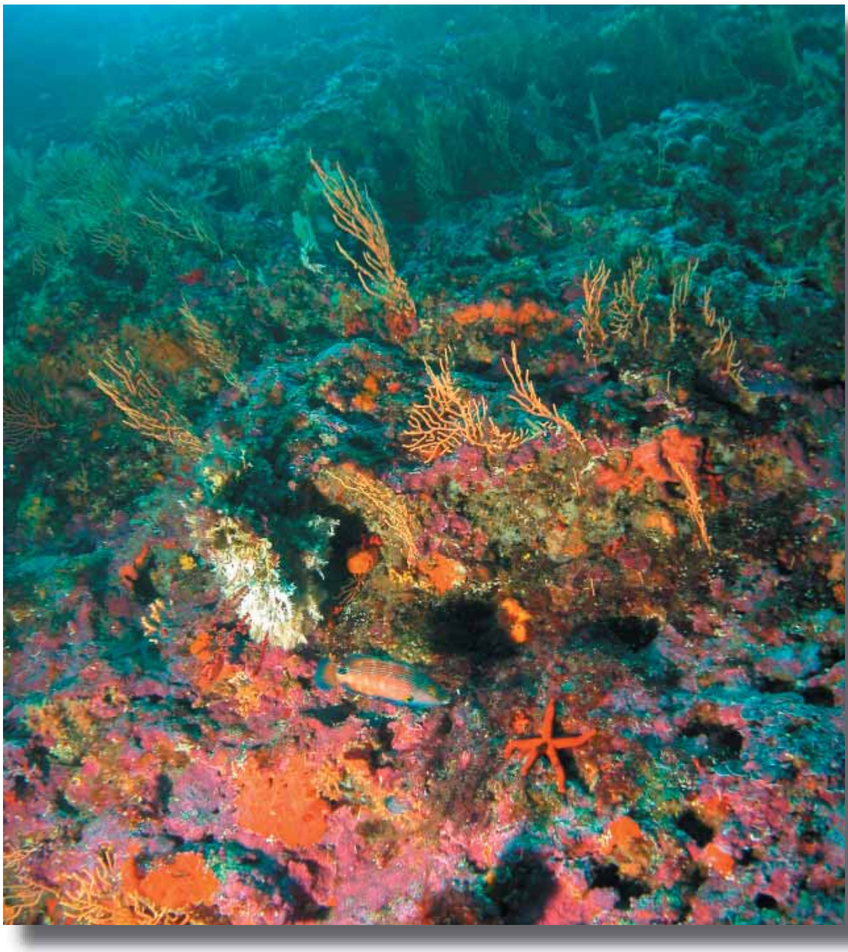
This Structure that builds progressively can be attacked by diggers of calcareous substrates (microphyts, sponges, cliones, some mollusks or grasers like *Lithophaga*). The balance between construction and foraging builds a three-dimensional structure highly anfractuous with a high variety of adjacent micro-habitats

II - Ecological importance

This spatial heterogeneity results in a very high **specific richness** (more than 600 species for a single area).

These coralligenous areas are a real eco-ethological crossroads for scientists. Along the coasts of the north western Mediterranean sea, they shelter more than 1700 species, which includes 300 species of algae, 1200 invertebrates, and a 100 species of fish.

In addition to its ecological importance, is a major economical one: coralligenous areas along with ship wrecks and caves are the places the most sort after by divers. Emblematic species like the dusky grouper, magnificent landscapes of submarine walls covered with gorgons constitutes attractions for underwater tourism.



III - Sensitivity and vulnerability

In coralligenous concretions, the construction of the structure happens very slowly, hardly a millimeter per year, and by successive layers.

The large upright species of invertebrates which are characteristic of these coralligenous concretions also have a very slow growth rate: for example many tens of years for a gorgon.

Several thousands of years are therefore needed for large coralligenous concretions to be created. Furthermore the most superficial layers, which are the more recent, are not yet well consolidated and are easily destroyed by mechanical shocks.

Likewise hard substrate coralligenous formations which develop in thin layers can easily be eroded too.

The large upright elements (gorgons, sponges) are relatively flexible and even if they are damaged, they rarely break as a direct result of a mechanical shock.

In contrast to this the substrate to which they are attached, red calcareous algae is much more fragile. Therefore these large upright elements will often be ripped out rather than broken.

The great vulnerability of these coralligenous environments is due to:

1- their very slow growth rate (which is also their rate of recovery)

2 their relative absence of mechanical resistance, at least for the superficial layers.

A mechanical shock or repeated rubbing will therefore quickly result in a total erosion of the top layers.

The large upright elements which give this particular physiognomy to the coralligenous landscape will also be the first victims of these impacts , due to either their size (large bryozoans) or the weakness of the anchor point on the substrate (gorgons, sponges).

This effortless erosion of the first layers of the coralligenous will undoubtedly have important impacts on all the other micro-habitats.

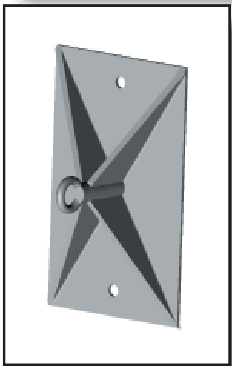
These coralligenous concretions are entirely made up of micro-habitats. In addition to the visible impacts there is also all the indirect and invisible impacts.

ADAPTED MOORING TECHNIQUES

Grouted anchor : see also grouted anchor in Part 1, Boulders and bedrock

I - Definition

Hard substrate coralligenous formations are an environment in which the original substrate is rocky.
The technique of grouting into rock is accordingly adapted, but the great vulnerability of this environment and its relatively weak mechanical resistance, necessitates particular precautions when using this anchoring technique.



II - Model description

Basically the models adapted to hard substrate coralligenous formations have the same general shape and principles as the ones for the boulders and bedrock environment.
However parts must be optimized in order to find the best balance between the required pull out resistance and minimal surface area of contact with the substrate. Knowing this, it is preferable, where possible to grout an individual rod of a larger diameter and embedded deeper into the rock.

Concerning the plates themselves, any surface that is not indispensable must be removed, in order to protect the environment.

III - Ecological benefits

The great vulnerability of this environment totally justifies the use of this technique for which the impact is negligible.
The installation is straightforward and does not require heavy equipment or techniques that could create secondary degradations.

The precise positioning of the holes allows the most appropriate location to be chosen.

IV - Holding principle

The pull out resistance of the grouted anchor is excellent if the quality of the rock provides a good mechanical resistance.

V - Installation technique

A lot of care must be taken when looking for the intended position of the anchor.
A rocky substrate of good quality must be chosen while minimizing the impact on the coralligenous formations.
The rod must be grouted into the rock underneath the coralligenous layer.
During the installation the following precautions must be taken: avoid secondary impacts, stabilize the working boat without anchoring in the area, use hangers under the boat to attach the equipment needed, instruct the underwater workers on how to act in this fragile environment.
In addition, avoid contact between the equipment and the bottom and the rock face; relieve the hydraulic hoses of their weight with rigid floating devices in order to obtain at depth a slightly positive or neutral floatability.

Recommendations:
Time has to be taken to assess the nature and the quality of the rocky substrate chosen. It is s not always easy to identify the presence of cracks and faults. They are often hidden by coralligenous algae.

In order to avoid problems created by electrolysis reactions, it is recommended to make the equipment out of materials of the same quality. The proximity of different materials such as standard steel, stainless steel, aluminum, copper, bronze and other alloys must at all costs be avoided. This rule must also be applied to the metallic parts that can be present in the mooring line, or attached to the anchor (shackles, eyes, etc.).

Solutions and estimated cost

- L= length in mm - TØ = shaft diametrer in mm - FSS = sub-surface float, diameter in mm - BRCC = rigid buoy with central chimney	- Estimated cost of supplies in euros (without tax and delivery cost) - All dimensions in mm - Floating line: rope linking marking buoys together and fastened to these - Floating structure : a swimming platform of 4 x 4 m on a swinging mooring

Grouted anchor

LIGHTWEIGHT BOATS < 7 METERS Ringbolt L 250, TØ 20, Polyamide line Ø 18 , buoy FSS 11 litres + BRCC Cost anchor only: 50 e
MEDIUM WEIGHT BOATS 7 TO 11 METERS Either Ringbolt L 250, TØ 20. either small plate with 2 bolts 250 X 20 Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: ringbolt 50, plate 550 e
HEAVYWEIGHT BOATS 12 TO 18 METERS Plate with 2 or 4 bolts L 250/300, TØ 20/24, depending on the rock type. Polyamide line Ø 24/30, buoy FSS 11/25 litres , BRCC 650 Cost anchor only: 550 to 650 e
MARKING BUOYS Buoy 400/600/800 Ringbolt L 200/300 TØ 16/20 Polyamide line Ø 14/16, chain 12-16 Buoy FSS 6/8 litres Cost anchor only: 35 to 50 e
FLOATING LINE Ringbolt L 250/300, TØ 20 Polyamide line Ø 14/16 , chain Ø 12 / 16 mooring buoy FSS 6/8 litres Cost anchor only: 50 e
FLOATING STRUCTURE Either ringbolt : L 250, TØ 20, either small plate with 2 bolts 250 X 20. Polyamide line Ø 24, buoy FSS 11 litres, swivel 20 Chain in mid-water 20 Cost anchor only: 50 to 550 e
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

Ecological moorings on Posidonia meadows

THE ENVIRONMENT

I - Description

Posidonia oceanica (Linnaeus) Delile is a marine **phanerogam endemic** to the Mediterranean sea and which makes up massive underwater prairies, meadows , also called seagrass beds from the surface down to 30 to 40 meters in clear waters.

Posidonia meadows are most often installed on soft substrates (fine to coarse sand) or in some cases on rocky substrates. The bathymetric limits of the distribution of the seagrass is characteristic of the **infralittoral** zone

Posidonia as a **phanerogam** has leaves, roots, a stem and can reproduce by using its flowers. A Posidonia shoot is a part of the rhizome carrying 7 to 10 leaves of different lengths .The youngest and shortest being situated in the center of the shoot. The rhizome can grow horizontally (it is called plagiotropic) or vertically (it is called orthotropic).

Whatever the direction of the rhizome the distance between the rhizome and the substrate is called the **baring**. Even when uncovered by the sediment, the rhizome is attached to the substrate by its roots

Upright in open water, leaves can reach a length of 1 meter. It acts as a screen that efficiently reduces the movement of the seawater.

Transported by the current, the finest particles are trapped and settle in the seagrass meadows between the rhizomes. The finest particles will inevitably cause the rhizomes to be buried. The vertical growth of the rhizomes is a way to counter act this situation.

This results in the development of a structure where rhizomes, roots, and sediments are interwoven. It is the **mat** of the seagrass bed.

The reproduction of *Posidonia oceanica* is mainly vegetative and rarely sexual . The flowering of *Posidonia oceanica* is indeed hardly ever observed, at least in the case of the north western Mediterranean sea.

The vegetative reproduction (duplication of the rhizome) produces a vertical or horizontal growth of the seagrass bed. In addition to the vertical development of the **mat** (already described), this growth allows the seagrass bed to colonize extensive horizontal surface areas (however at a very slow rate: less than 10 cm per year).

The vast stretches of seagrass must therefore be considered as monumental constructions slowly assembling throughout the centuries. Any significant destruction is therefore on a human scale, quasi non reversible. These vast areas can be continuous or discontinuous, depending on the level of cover (0 % - no seagrass to 100 % - continuous seagrass bed).

Hydrological events can also cause the appearance of structures without vegetation, that is to say without shoots of posidonia; these are intermats and intermat channels . The erosion and the topography, at a local level, result in the appearance of **mat** cliffs, of a few decimeters to a few meters high .

Erosion , whatever its cause , can also result in the appearance of a surface area covered by dead mat, areas where dead rhizomes with no leaves are exposed .

In the majority of cases the growth of a seagrass bed happens on soft substrates.

A theoretical ecological succession of phases has been described with the installation first of meadows of Cymodocea (see Part 1, Sand and mud) on soft sediments (fine sand) then as time goes with the appearance of Posidonia meadows. If the succession stays theoretical, it is certain that the vertical growth of the seagrass bed of Posidonia is bound to happen.

When the leaves reach the surface the structure that is formed takes the name of “barrier reef”. This terminology is adopted because this event is observed in most cases at the bottom of bays where the exposed leaves form an arc parallel to the shore in a very similar way as fringing coral reefs.

The space created between the barrier reef and the shore works as a lagoon : *Cymodocea nodosa*, another marine **phanerogam** is found in these conditions optimal for development.

When these ecological conditions and the health of the meadow is good, Posidonia can grow on rocks to give a unique construction: bedrock meadows. The **mat** is therefore relatively thin, the **baring** is limited and the shoot density is high.

II - Ecological importance

Posidonia meadows are today considered as one of the most important ecosystem if not the key ecosystem of all Mediterranean coastal spaces.
Similar to a forest on land, the Posidonia meadow is the final event of a succession of populations. Its presence is the essential factor for the ecological balance of many Mediterranean coastal ecosystems.
The seagrass bed has an impact on the quality of coastal waters (production of oxygen, trapping of sediments). It represents a peak of biodiversity (20 to 25% of vegetal and animal species are found there) and are at the base of a number of food chains.

The meadow is a home, a **spawning area** and a **nursery** for a number of animal species who find their food, refuge and protection. It also plays a fundamental role in the protection against erosion of the coast and the beaches, without which the actual coastline would be greatly altered.

The vegetal **biomass** produced in a meadow is considerable. In a surprising way, very few herbivorous benefit: in the western Mediterranean sea only the herbivorous fish, Salema (*Sarpa salpa*) and a few invertebrates (sea urchins) feed preferentially on it. The major part of this primary **production** is hence exported to other environments, mainly in the guise of dead leaves.

If the invertebrates are not feeding only from Posidonia, they do contribute to breaking up this vegetal **biomass**. It then becomes more available for the other trophic levels.
The hydrodynamic forces from the waves and the current that sweep the seagrass bed significantly contribute to the dispersion of these fragments of leaves.

A number of ecosystems, coastal or deeper benefit from this exportation of organic matter to insure their existence. This undeniable ecological importance has promoted concrete actions to protect the meadows: French Statutory Order for the Protection of Posidonia (19 July 1998), decree law (20 September 1989) of the “Loi Littoral” (3 January 1988) and European Directive for the conservation of natural habitats (21 may 1992). Marine seagrass beds are also taken into consideration by Unesco since the Rio Conference in 1992.

Finally, the global economic importance of the seagrass is undeniable and along with estuaries they are major environments: their economical value is estimated as three times that of the coral reefs environment.

III - Senstivity and vulnerability

Posidonia meadows or the areas of dead **mat** are characterized by a highly variable mechanical resistance.
The **mat** can present a level of **compaction** highly variable according to the nature of the sediment, found : fine particles in the sediment will give a lower level of **compaction**; fine and coarse sand with a few fine particles considerably increases the level of **compaction** of the mat.

The mechanical resistance of the seagrass bed to an external impact will therefore be very different.
Furthermore an important **baring** of the rhizomes accentuates the sensitivity of the meadows to mooring pressure: a **bare** rhizome distant from the sediment will be more easily ripped out by an anchor slid underneath the rhizome layer next to the substrate.

Moreover, the ecological importance of seagrass is linked in a great part to its three-dimensional structure. Repeated actions of ripping-out shoots by anchors can provoke a deep modification of this **bio-construction** and as a consequence a probable reduction of its ecological role.

As an interface between the terrestrial and the offshore zone, seagrass beds are probably to date the environment that has suffered the most from anthropogenic impacts. The reasons for these regressions are numerous. They are for a great majority created by nuisances of an anthropogenic origin like domestic pollution, constructions on the coastline, pollution from industries, use of trawl nets.
For several years numerous authors have alerted scientists and governing bodies to the problem of the damaging impact of temporary moorings on the Posidonia seagrass.

By their extent and their reputation of being a good anchoring ground, the seagrass is often the victim of leisure boat activities.
The investigations carried out clearly show that the large majority of leisure boats prefer to anchor on seagrass beds rather than on other bottoms (sand, rock) in order to have a secure temporary mooring.

Recently several studies have clearly indicated and quantified the impact of boat anchors on the seagrass. Studies recommend without reservation, when it's possible the use of other methods than boat anchors.

ADAPTED MOORING TECHNIQUES

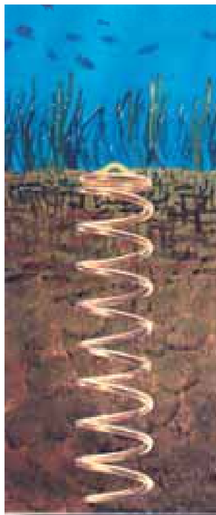
The steel coil anchor Harmony type P.

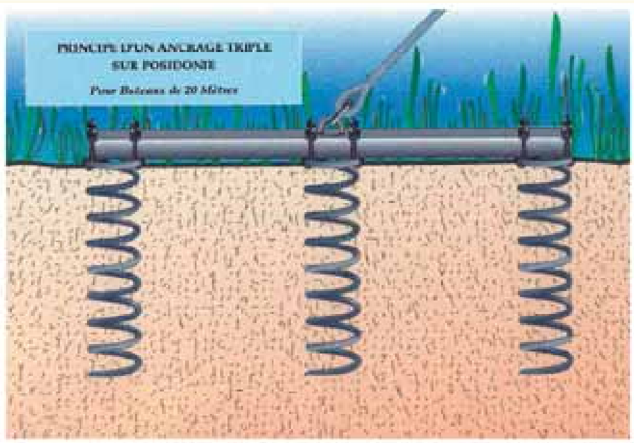
I - Definition

The steel coil anchor Harmony type P. is a device made of a steel coil (in the shape of a corkscrew) where the wire, the exterior diameter, the length and the pitch enables the penetration into the substrate, particularly the seagrass mat, to give a strong anchoring point.

Perfectly adapted to all types of seagrass mat, living or dead, the range of use is very wide :mooring of small boats to large vessels.

In certain conditions the meadow develops on rocks, the thickness of the **mat** is hence really low. In this situation, the technical solutions described in part 1, “Boulders and bedrock” can be used with special care to avoid damaging the seagrass.
In the case of a very sparse Posidonia meadow with isolated shoots where the substrate isn’t really a **mat** but is sandier, the sand screw technique must be used. The steel coil anchor Harmony type P. permanent mooring is reversible and can be removed and reused on other locations.





II - model description

The steel coil anchor Harmony type P is made of special heated galvanized steel.

Depending on the projected use and the maximum load expected there are models which vary in length.

As general rule, the average values characterizing the steel coil anchor are:
-diameter of the wire : 30mm
- exterior diameter : 350 mm
- length: 800 to 1600 mm,
- weight:25 to 42 kg.

The anchoring points are made of clamps with loop-holes attached to the top turn. It is easily removable to be placed elsewhere. These coils can be installed individually or attached together in a line of 2 or 3 with a coupling bar.
These models are under an extended European patent.

III - Holding principle

The steel coil permanent anchor penetrates the seagrass **mat** with its whole length by screwing.
This **mat** is made up of a dense network of entangled rhizomes and plant roots.
The very rigid wire of this giant corkscrew creates its own path through this network without cutting, crushing or destroying the elements which constitute the seagrass mat.
It is the absence of degradation of the **mat** which will gives an excellent pull-out resistance to the mooring.

Under traction, the coil harnesses an enormous volume of soil around itself because the efforts are distributed throughout the whole rhizomes network.

IV - Ecological benefits

The installation of a steel coil permanent anchor in a healthy seagrass bed does not have a negative impact. This is the conclusion of a scientific study.
The shape of the anchor does not affect neither the leaves nor the plant rhizomes. No surface area of the seagrass bed is covered. There is no **scouring** created if the system is screwed well enough into the substrate. There is no alteration of the **mat** during the installation. The implementation of the steel coil anchor does not require heavy equipmentthat may create secondary degradations.

V - Installation technique

Manual screwing

This technique can be considered only with small models (short length). With the use of a lever going through the 2 loopholes mounted on the top turn, 2 underwater workers facing each other turn the anchor until it is completely screwed into the mat.
The limitation of this technique is linked to the physical force developed by the workers arms and by the length of the lever used.

This method of installation is technically possible but is not recommended due to the stamping on the seagrass during the manual screwing.

Hydraulic machine assisted screwing

This technique enables:
- important **screwing torques** if needed
- the ability to work at any depth while controlling the power, avoiding physical efforts of the underwater workers
- finally avoiding stamping on the seagrass bed.

The required equipment includes:
- a hydraulic power unit
- 2 hydraulic hoses of sufficient length
- a hydraulic screwing gun with a special head for holding the steel coil. This tool has two arms to be used by the divers.

The divers are standing on the ground and are working as anchor points doing no excessive efforts. The screwing-in using a hydraulic machine is by far the best installation technique.

Recommendations:

The best choice of substrate and anchor device must always be found.
The conditions of use must be properly identified as well as the wind, wave height, volume and nature of the object (boat, pontoon, buoy) that it will be supporting.
A calculation of the maximum wind speed and wave height will allow an estimation of the maximum effort that will be supported by the projected moorings.
Always use non aggressive techniques for moving the anchor parts and the installation equipment (tow the equipment with a float, careful choice of place to the temporay anchoring of the working boat, etc.).

The mooring needs to be completely screwed into the sediment. In the case of an incomplete screwing, the steel coil should be unscrewed and moved to another place to be properly set up.

VI - Choice of model

A/ According to its use
It is the required pull-out resistance of the anchor that will determine the choice of model. As a general rule, the resistance is proportional to the total length of the anchor.

B/ According to the quality of the substrate.
The mechanical resistance of the Posidonia **mat** varies greatly due to its variable **compaction** level. This **compaction** level is linked to the density of the Posidonia seagrass bed (number of shoots per square meter) and to the nature and grain size distribution of the sediment trapped.
This guide does not set out to calculate accurately this resistance which can be done by soil stability specialists with the use of tools like **penetrometer**, **vane tester** and core sampling apparatus.
It is however necessary to check the available thickness and **compaction** of the seagrass **mat** and to put it in relation to the minimum length of the anchor to be installed.

With an identical load on mats with different **compaction** levels, the lower the level of **compaction**, the more the anchor will need to be long to have a better resistance to lateral forces, and the more the numbers of coils for a single mooring will be needed.
The more the **mat** is compact, the more the anchor will need to be of «normal proportions» and the coupling of 2 or 3 coils together is needed only for very heavy objects

According to the estimated effort.
The steel coil permanent anchor has standard sizes of 0,80 m to 1,60 m.
Above this size, installation techniques become more complicated. The equipment has to be bigger and the whole installation can have a significant impact on the environment (repeated movements of boats and temporary moorings, repositioning).
It is therefore more important to increase the number of anchor points to divide the load than to make one single large steel coil anchor.

With a similar level of **compaction** of the seagrass mat, the higher the pull-out force is, the more the anchor points will need to be coupled together (multiple anchor points can even be coupled to each other).

Dramatic confusion
A sand-screw must not be placed in the seagrass bed for many reasons.
The cutting edge of the sand-screw disc during its rotation will cut or pull-out the shoots at the surface of the soil and along the whole path of the screw.
The rhizomes will be broken, ripped-out or crushed.
This destructive impact brings with it another consequence: the mechanical resistance of the **mat** is decidedly weakened by the breaking up of the three-dimensional structure of its elements which means that the pull-out resistance is very low.

SOLUTIONS AND ESTIMATED COST

- L= length in mm - ExtØ =external diameter of the coil in mm - FØ =wire diameter in mm - FSS = sub-surface float, diameter in mm - BRCC = rigid buoy with central chimney	- Estimated cost of supplies in euros (without tax and delivery cost) - All dimensions in mm - Floating line: rope linking marking buoys together and fastened to these - Floating structure : a swimming platform of 4 x 4 m on a swinging mooring

STEEL COIL ANCHOR HARMONY TYPE P.

LIGHTWEIGHT BOATS < 7 METERS Coil : L 1000/1200, ExtØ 350, FØ 30 Polyamide line Ø 18 , buoy FSS 11 litres + BRCC Cost anchor only: 300 e
MEDIUM WEIGHT BOATS 7 TO 11 METERS Coil : L 1500, ExtØ 350, FØ 30 Polyamide line Ø 20 , buoy FSS 11 litres + BRCC Cost anchor only: 400 e
HEAVYWEIGHT BOATS 12 TO 18 METERS Coil : L 1500/1600, ExtØ 350, FØ 30 Polyamide line Ø 24/30, buoy FSS 11/25 litres , BRCC 650 Cost anchor only: simple 450 e, double 1200 e, triple 1500 e
MARKING BUOYS Buoy 400/600 Coil : L 800/1000, ExtØ 300, FØ 22 Buoy 800 Coil : L 1000/1200, ExtØ 350, FØ 30 Polyamide line Ø 14/16, chain 12/16, buoy FSS 6/8 litres Cost anchor only: 250 to 300 e
FLOATING LINE Coil : L 1500, ExtØ 350, FØ 30 Polyamide line Ø 14/16 , chain Ø 12 / 16 Buoy FSS 6/8 litres Cost anchor only: 400 e
FLOATING STRUCTURE Coil : L 1500, ExtØ 350, FØ 30 single or double Polyamide line Ø 24, buoy FSS 11 litres, swivel 20 Chain in mid-water 20 Cost anchor only: 450 to 1200 e
IMMERSED STRUCTURES Depending on the nature of the object and its floatability, a specific study is needed

Part 2.

Sensitivity and vulnerability of the habitats. Summary

Sensitivity and vulnerability

	Sand and mud	Pebbles and cobbles
Pull-out resistance (holding power)	low	medium
Resistance to a shock	good	good
Stability of the substrate	good stability of the substrate	very low stability of the substrate
Three-dimensional structure	none, variable slope	none, variable slope
Bio-construction	absent	absent
Other characteristics	Suction effect can be important (mud). Quick dispersal of *C. taxifolia* and *C. racemosa*	
Ecological importance	high	limited
Sensitivity and vulnerability	**medium to high (if *Cymodocea or Zostera*)**	**limited**

The sensitivity and vulnerability of an habitats can be appreciated in relation to its different characteristics: mechanical resistance (holding power of an anchor), resistance to a shock, stability, three-dimensional structure, presence of **bio-constructions** and ecological importance.

A permanent mooring does not need to be in a specific location and a manager can always have the choice between different substrates.

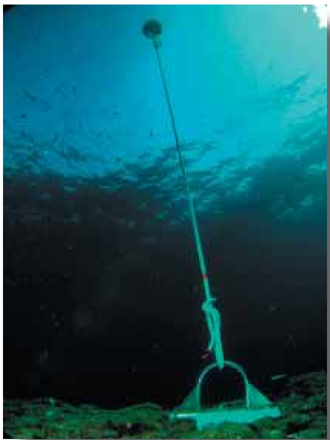
Even if different ecological anchoring techniques have been described, it necessary to choose, when possible, the environment which is the least sensitive and vulnerable. Theoretically any habitat, whatever it is, will suffer a negative impact. However the consequences at the level of its ecological organization or its organic integrity will not be the same. Ecological quality and integrity will not be damaged in the habitats the least sensitive and the least vulnerable .

of the habitats - Summary

Boulders and bedrock	Coralligenous formations	Posidonia meadows
good	good	variable
good	low	variable
variable stability of the substrate	good stability of the substrate	good stability of the substrate
From variable slope to very significant relief	high (concretions)	high (mat)
absent	yes (concretions)	yes (mat)
potentially high heterogeneity of the substrate		vulnerability depends on the **baring** of the rhizomes and the compaction level of the mat
high	very high	very high
medium to high (for upright species)	**very high**	**high to very high**

On the contrary in environments which are the most sensitive and the most vulnerable, the integrity of the habitats can be damaged with the destruction of its spatial architecture and simplification of its complexity.

The **specific biodiversity** of a **biocenose** is closely linked to the diversity of its habitats and its spatial complexity. The destruction of its spatial architecture can have major consequences on the way it works (disappearance of species, reduction in the **production**).



Part 3.

Intermediary and surface elements

INTERMEDIARY ELEMENTS

I - Definition

Intermediary elements are all the elements situated between a fixed mooring point (anchor) and an object or a structure.

This system is designed to ensure the fastening between these two elements in order to make them connected.

In this guide, the whole link is called the mooring line.

II - Principle

The mooring line ensures that the movement of the object which is attached is either limited or immobilized.

All the forces applied (wave, wind, current) on a moored object generate an effort, mainly horizontal, that is entirely transferred by the mooring line to the anchor point on the seafloor.

The intermediary elements or mooring line are therefore under variable and important stress.

The tension in the mooring line changes according to 2 parameters: the value of the horizontal effort and the value of the angle between the mooring line and the horizontal.

The working angle will therefore be one of the parameters to be taken into account when designing a mooring line.

As an example,

Horizontal load	Angle	Tension
1 ton	0°	1 ton
1 ton	30°	1.2 ton
1 ton	60°	2 ton
1 ton	80°	5.8 ton
1 ton	85°	11.4 ton

III - Design

The mooring line must be perfectly adapted to the use as well as the working conditions.
The parameters to be taken into account in the design of the mooring line are: the resistance, the length, the absorbing effect, the life span, the maintenance and the reduction or the absence of negative impacts on the environment.

There are several options for the mooring of an object.

Mooring on a single mooring line:
On a swinging mooring where the object can freely move 360 degrees around its anchor point will always face the wind or the sea.
This system of free swinging gives flexibility and smoothness in movement and reduces to a minimum the potential load applied to the mooring object.
On the surface the swinging circle can be a problem in the management of the mooring area.
Swinging moorings are recommended on sites exposed to wind of variable strengths and direction.

Mooring on two opposite mooring lines:
Mooring head and stern. The object can move only on a fore-and-aft axis with a limited lateral movement.

This system which greatly reduces the movements provokes jerks and therefore increases the power of the dynamic efforts.
When the wind and the sea come from the side of the object moored (head and stern mooring), the surface areas exposed to these forces are much higher than the surface areas exposed in the case of a facing wind.
Care must be taken to allow free vertical movements of the objects moored.
The head and stern mooring reduces the required surface area on the water , but puts more stresses on the mooring points , the mooring lines and the an-

chor points .
The head and stern mooring is recommended on sites which are relatively sheltered with a wind of constant direction which will influence the orientation of the equipment to be installed.

Multi point mooring
This technique allows the almost total immobilization of an object in the horizontal plane.
This is the case for the mooring of a floating pontoon perpendicular to a dock for example or for an isolated platform. In these cases the mooring lines will be designed to allow vertical movement of the structure held.

Tightly drawn mooring
The length of the mooring line will not allow any vertical movement of the moored object. The position of the object is stable but the resistance of the mooring line must be much higher than the value of the Archimedes force provoked by the total immersion of the object moored

IV - Resistance

The required resistance will be calculated with regards to the maximum theoretical load transferred by the mooring line according to the given conditions of use.
The tension will be estimated with the angle which creates the biggest pull out force. The value obtained must be multiplied by a safety coefficient to take into account the extreme values of the dynamic forces and the possible wearing of some elements (shackles, etc.).
The mooring line must have over its whole length an homogeneous resistance.
The individual resistance of each of the components (shackle, chain, cable, rope, swivel, etc.) must be checked.
The fastening techniques (knots, splices, whippings) used must not create weak links.
The resistances given by the manufacturers are provided in terms of breaking values or maximum working load without a safety coefficient or in terms of maximum working load with a safety coefficient.

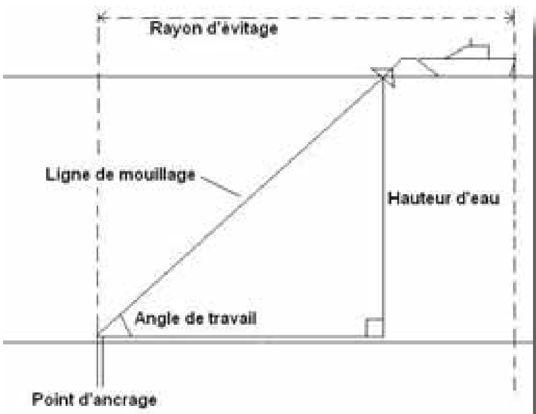
V - Length (except for tightly drawn mooring)

This length will be calculated with the parameters of water height (spring high water added to the possible wave height) and the desired working angle under those conditions.

The total length of the mooring line will therefore be equal to the hypotenuse of a right angled triangle for which the height is equal to the maximum water height and the angle adjacent to the base is the working angle of the mooring line.

To maintain appropriate tension it is recommended that the maximum angle be 45 degrees.
For this value the tension in the mooring line will be equal to the horizontal load multiplied by 1.414.
Furthermore the working angle of 45 degrees is a good compromise between tension and swinging space.

If the working angle decreases, the tension decreases but the swinging space increases.



VI - Absorbing effect

The absorbing effect is desirable in order to reduce the jerking provoked by the swell and the backwash on all the mooring elements.
The opposite force required to absorb the movements has generally been a ground mooring chain attached to the anchor point on the bottom (see “deadweight mooring” in Part 1 “Sand and Mud”).
This efficient technique is not used anymore because of its negative impact on the environment (constant swing and banging of the chain over the substrate) .

Another technique uses the Archimedes principle with an immersed float attached at mid depth on the mooring line.
This float of sufficient volume maintains with its pull the lower part of the mooring line tightened vertically.
This permanent vertical pull acts as an opposite force to the horizontal load applied on the object moored.
The absorbing effect will be proportional to the volume of the sub-surface float installed.
This effect is also increased by the drag created by the movements of the immersed element (relation between the speed, the surface area and the density of the fluid).

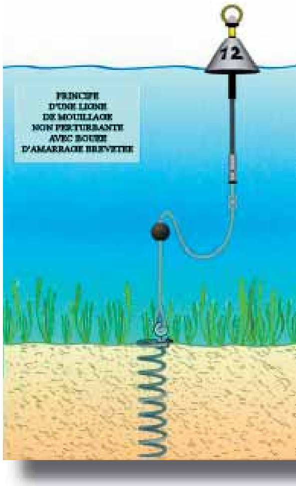
This solution has two major advantages: the absorbing effect of the movements and the absence of negative impact on the environment. In fact the pull of the float stops any contact of the mooring line with the substrate.

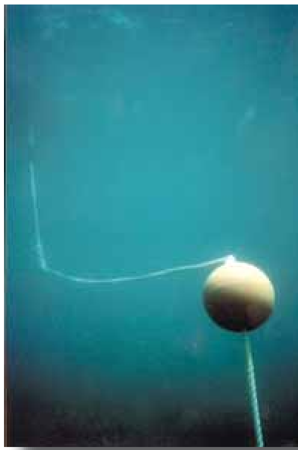
A mixed solution uses advantages of both techniques. A sub-surface float is installed at mid depth and maintains the tension in the first part of the mooring line, which is made of rope. The second part between the mid depth float and the surface is made of a chain of large diameter.
The pull of the float acts as a first shock absorber while the length and the weight of the hanging chain absorb the larger jerks.

The volume of the float is calculated to obtain a significant pull irrespective of the weight of the hanging chain.
The position of the float and the length of the chain are chosen so that no contact of the mooring line with the substrate is possible.

The material used for a mooring line can in itself have an absorbing effect because of its mechanical characteristics. This is the case for example with a polyamide line with 3 strands: at 75% of the breaking load the lengthening is 45%.

There also exists specific elements designed to be shock absorbers (spring, elastomer, etc.).





VII - Life span and maintenance

The life span of a mooring line is linked to its design (good adaptation to its use) and to the quality of its components.

Simple and efficient assembles are always recommended. To increase the life span, wearing must be avoided.
Any movement creating a friction causes wearing (e.g. a shackle in the eye ring of a buoy, or a shackle in a swivel, or a shackle in a thimble).
It is therefore important to look for assembles where the incessant movements of the parts are avoided.
It is recommended to use intermediary rings between shackles and eye rings, as well as replacing intermediary links such as shackles and thimbles with closely tight knots.

In the case where the chain works as a weight (e.g. under a mooring buoy) it is preferable to use a shorter chain of a large diameter rather than a chain of small diameter and longer length.
This type of chain wears much quicker because of the electrolysis and the friction of the links against each other.

A monobloc weight such as a piece of cast iron can be used to replace a chain. It must be fastened to a textile rope and if it is at a good distance from the floating buoy, it will not be especially worn out.

VIII - Ecological benefits

The mooring line equipped with an intermediary float which remains, whatever the conditions, in mid-water without direct contact with the substrate, presents and undeniable ecological advantage of the highest order.

All of the substrates on which this type of non disturbing mooring line will be installed will benefit .

IX - Choice of materials.

As a general rule, the material used for mooring lines is metallic, textile, polymer, or a combination of the last two.

All the metallic materials are resistant but will always be corroded due to oxidation or electrolysis.
All types of chain wear out quickly due to shocks and friction provoked by repeated movements.

All the flexible materials of a textile type (polyester, polyamid, polypropylen, polyethylen, etc.) stranded or braided are very strong and resistant to most of the chemical or organic agents. However they have a very low resistance to mechanical wearing due to repeated friction against any object.

The ratio resistance/life-span will be in favor of textile elements as long as these are properly protected from friction and **chafing**.
All ropes with an external braided sleeve in polyester are well resistant to friction and abrasive wear.
Braided ropes of 8 strands (4 x 2) in polyamid are well resistant to unstranding.
Polyamid ropes with 3 strands have a good lengthening ratio and absorb shocks well.
Textile cables with a core braided in aramid (Kevlar) and with an outer sleeve braided in polyester have a ratio resistance/life-span exceptionally high (e.g. diameter 17.5 mm, resistance 20 tons, weight per meter 242 grams).
Some ropes are a combination of textile and metal, it is the mixed ropes, e.g. polypropylen rope with multi strands where the core of each strand is made of a steel cable.
This rope resists fairly well to **chafing** and maintains a reasonable flexibility.





X - Recommandations.

Materials of good quality must be used especially for shackles where the thread of the shackle pin becomes often quickly oxidized.
The shackles must always be block wired (the shackle pin is held by a tie to avoid being unscrewed). It is preferable to use a nylon tie rather than a metallic wire.

The slack between the various fastened elements (shackle, thimble, eye ring, chain, swivel) must be minimal.
The chains are permanently being worn out because of the movement of the links with each other. In order to reduce this wearing, for an identical weight it is preferable to have a short chain and of large diameter , than a longer chain of smaller diameter.
A mixed rope for all or part of the mooring line is a good replacement of a chain.
The installation below a buoy of a polyamide line with a tubular weight of steel or cast iron placed a few meters below the buoy is an excellent long term solution. It is then only necessary to protect the upper section in polyamide from propellers with the use for example of a PEHD tube.
The potential electrolysis between the different parts must be checked. The mechanical abrasions must be avoided on all the textile parts. If necessary the parts have to be protected with braided sleeves, sections of polyethylene tubes or protections in PEHD.

A few benchmarks
A shackle mounted to a chain must be of a diameter just above that of the chain (e.g. chain 14 mm, shackle 16 mm).

Average lengthening at 75 % of the breaking load	
Steel cable	2.5%
Coaxial polyester	17%
Coaxial polyamide	22%
8 strands polypropylene	25%
3 strands polypropylene	27%
8 strands polyester	28%
3 strands polyester	32%
8 strands polyamide	35%
3 strands polyamide	45%

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Ømm	Chain	polyamide
8	2300	1330
10	4300	2040
12	5000	2940
14	7000	4020
16	9000	5200
18	11500	6570
20	14000	8140
22		9800
24		11800
30		17400

Compared resistances in tons between chain and 3 strands polyamide rope.

Boat length	Displacement	Ø mm
8 m	2 - 4 t	12 -14
10 m	5 - 6.5 t	14 - 16
12 m	8 - 11 t	16- 20
16 m	12 t	20
20 m	20 t	24

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Moorings : recommanded diameter for a 3 strands polyamide and a 3 strands polyester rope

Surface elements

I - Mooring buoy for boats

Definition :
A mooring buoy is a floating buoy that locates the presence of a mooring system and that holds a line available for the user.
The mooring buoy in certain situations is reduced to a simple marker buoy equipped with a small line allowing the collection of a mooring line laying on the floor. But as a general rule for security reasons, ease and comfort, the buoy combines functions.

Visual Signal: in the shape of a sphere or a cone, and often white, its size should permit it to be easily seen and to place information on it (N°, size of boat, limits of use, pictogram).
This buoy must be resistant, withstand accidental shocks against the hull and withstand UV rays and chemicals.

Mooring support:
The buoy is not a mooring element, it simply allows access to the mooring line to tie-up the boat correctly.
A mooring buoy is not designed to offer the mechanical resistance of an intermediary part between the bow line of the boat and the mooring line.
Numerous buoys are equipped with a rod going through their center and with an eye ring at the top and a swivel at the bottom.
These buoys are often badly used. In reality numerous boats moor directly to the top eye ring of the rod, however this eyering should be used only to catch the buoy, it is not a strong element of the mooring.

Choice of mooring buoy:
Numerous choices of buoys exist with varying designs and prices.

Inflatable spherical buoy with a central through rod.
This solution is cheap but is not longterm reliable and the material is often sensitive to UV rays. In the case of a puncture the buoy is not unsinkable. It is difficult to mark information on the float and the through rod creates incorrect usage.
The shape of the float requires ballasts to hold itself vertical and finally it is not easy to tie the bow-line of the boat to the mooring line hanging from below the buoy

Bi-conic shaped buoy with a central through rod
An unbreakable material must be chosen (e.g. PEHD is preferred to PVC) as well as a model where the interior volume is filled with foam to ensure a perfect floatability whatever happens.
The through rod can create an incorrect usage. The shape of the float requires ballasts to hold itself vertical and finally it is not easy to tie the bow-line of the boat to the mooring line hanging from below the buoy

Conic shaped buoy with a central chimney
The body of the buoy is made of PEHD and the inside volume is foam filled. It has a very good life span and if necessary can be easily marked.
There is no through rod and therefore no corrosion. Mooring on it is easy as the mooring line goes through the chimney and the loop can even be lifted up to 2.5m above the surface with the use of a protection tube slipping inside the chimney of the buoy.
This buoy is designed to be used with a textile mooring line and does not require a weight to be kept vertical.

II - Marking buoys

Marking buoys in general, and in particular the ones used for beaches, are standardized for each country.
They are in general yellow in color and of spherical shape for the delineation of areas.
According to the nature of the activity in the zone, the restrictions and prohibitions, the diameters used are between 400, 600 and 800 mm and the spacing is proportional to their diameter.
For France, the system of buoyage and the marking-out of the coastal stretch is noted in the Statutory Order of 27 march 1991 (J.O. 28 avril 1991).

Channel buoys are coned shaped if starboard (black or green) or cylindrical if portside (red); however channel buoys can also be yellow (access channels to beaches).
Buoys indicating a specific site as shown on marine charts can have various shapes.

It is advised to check the regulations in each country with the governing bodies concerned.

The equipment
A lot of manufacturers propose standard buoys and the choice will only be on the nature of the material, its robustness and unsinkability.

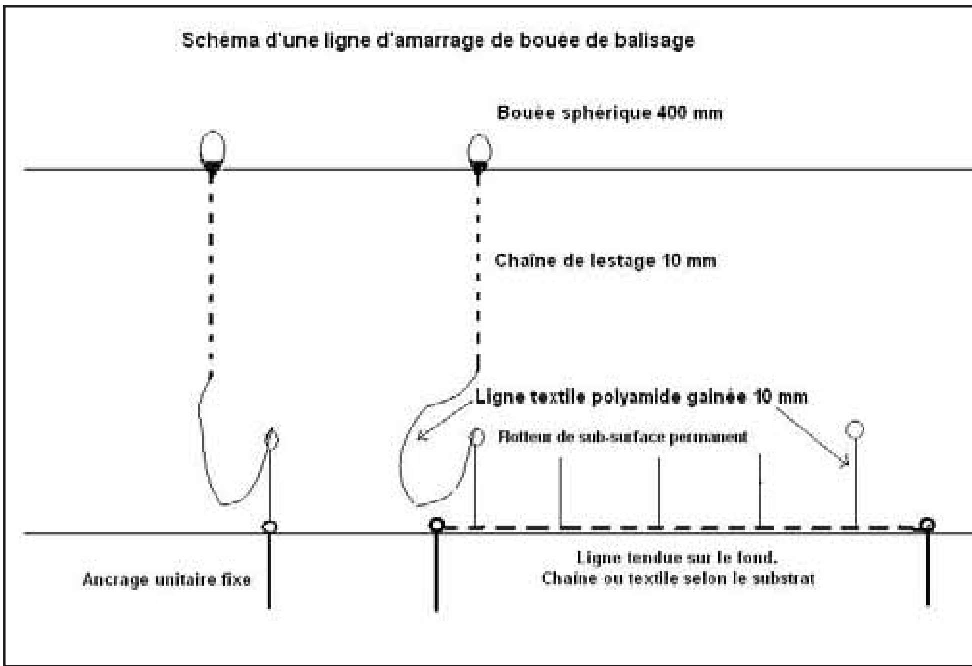
The buoys the most resistant are made of High Density Polyethylen (PEHD) roto-molded with an injection of polyurethane foam to ensure the unsinkability.

The eye ring of the buoy is protected and reinforced by a metal eye set tight into the hole. A buoy with these characteristics will be one of the most expensive models.

The installation
The installation of seasonal or permanent buoy in a traditional way creates a non negligible repeated impact on the environment. In practice the mooring lines are almost always made up of a ground mooring.
The length is always superior to the height of the water to take into account the **tidal range** and the swell.
Under each marking buoy, several meters of chain incessantly sweep and bash onto the substrate (it is that part of the chain which is worn-out extremely rapidly).
All that is needed is to replace or modify the mooring line to eliminate the negative impact. The technique described above has 2 advantages:

- absence of degradation: the ballast chain, shorter (but equivalent in weight) does not stay on the sea bottom.

- reduced wearing-out of the equipment: the vertical position of the chain in the water insures a much better life span.



III - Floating line

This equipement complements the marking buoys. Its goal is to reinforce the marking of an impenetrable barrier. It is often used to ensure a better protection for swimmers or visitors of underwater trails or to implement the ban of access to a totally protected area or a mooring prohibited area.

Depending on the country and site where this device is set up, it is necessary to check the potential consequences that it might cause. In France for example the establishing of buoys linked together by a floating line along the coast is often a creation of a zone reserved exclusively to swimmers. If it the case, this zone must be under the surveillance of lifeguards.

The equipment

The equipment is made of a polypropylene rope orange or "safety yellow" on which are threaded and fastened cylindrical floats approximately every 2 meters and have at the ends large spliced loops.

There are not many different materials in this type of equipment. Complete floating lines can be found of 10, 20, 25, 30, 50 and 100 meters.

The installation

The best setting must be found during the installation for the tension of the floating line.

It must not be extremely tight between 2 buoys. It is also important to protect from friction the contact points between the floating lines and the anchor points on the buoys. This connection must be fixed solid and protected by a sleeve of PEHD.

The mooring lines of the buoys used as anchor points to attach the floating line must withstand, without wearing, the movements of these floating lines.

IV - Floating or immersed structure

Whatever the type of structure, the anchor points receiving the mooring lines must satisfy the following criteria:

- the shape of the parts making up the anchor points must allow the forces to work in axial way in order to create a pull out stress and not a shear stress.
- the parts under stress must be sufficiently reinforced to transfer the load with no risk of breaking.

In the case of a floating structure anchored in a swinging mooring, two anchor points located up wind (end of the structure facing the wind) and both sharing the load enables the distribution of efforts and stabilization of movements. The same structure could also be moored from a single centre anchor point.

With immersed structures, the anchor points must be carefully placed in order to withstand consistently the Archimedes force affecting the structure.

Part 4.

Product suppliers - Contacts

These pages present a non exhaustive list of manufacturers, suppliers and service providers.

It is in no way the result. of a selection or a recommandation of the authors.
It is rather a business directory of companies which products are regularly used for the supply and installation of various ecological moorings in the north western Mediterranean.

This directory will expand with the experience and knowledge of all the managers of marine protected areas of the Mediterrean.

I - Mooring devices.

- Sand screw.
-Small and medium size models
Local or regional suppliers selling galvaniized or black chain and other maritime and harbor equipments.

-Medium and large size models
Neptune Environnement.
Ancrages Harmony
446 Rte des catalanes
83230 Bormes-les-Mimosas
France
+33 (0) 494 152 638
neptune.env@wanadoo.fr

- Dead weights
Companies doing harbour and maritime work. Companies selling prefabricated concrete products. Information can be obtain by contacting concrete plants

- Steel coil anchors for Posidonia
Neptune Environnement.
Ancrages Harmony
446 Rte des catalanes
83230 Bormes-les-Mimosas
France
+33 (0) 494 152 638
neptune.env@wanadoo.fr

- Grouted anchor
Threaded rods and anchor rings : from all stainless steel (A4) suppliers.
From supliers for the maritime and lifting industry (high resistance steel, stainless steel products A4)

- Anchor plates and special parts
At blacksmith and ironworkers working with stainless steel (doing laser assisted cutting or not)

- Underwater anchor grout
From suppliers of grout for the building industry. Company HILTY for example (require underwater use)

II - Mooring lines

- Textile ropes
COUSIN Trestec SA
8 rue Abbé Bonpain BP 39
59117 Wervicq Sud.
France
+33 (0) 320 144 000
contact@cousin-trestec.com

- All type of floats
MOBILIS SA
370 rue Jean de Guiramand
13290 Les Milles - France
+33 (0) 442 371 500
mobilis@mobilis-sa.com

- Accessories : thimble, shackle, swivel
From local or regional dealers seling black and galvanized chain.
From maritime and harbour equipment dealers
From supliers for the maritime and lifting industry (high resistance steel, stainless steel products A4)
Sté LEVAC to Lyon, Toulon, Alger
info@levac.fr
http://www.levac.fr

- Mixed rope, floating line
SIMA
88 rue Delbos BP 36
33028 Bordeaux Cedex
sima.france@wanadoo.fr

- Surface buoys
Mooring buoy, buoy with central chimney, marking buoy, etc.
MOBILIS SA
370 rue Jean de Guiramand
13290 Les Milles - France
+33 (0) 442 371 500
mobilis@mobilis-sa.com

III - Floating structures

- Modular collapsible pontoons
CUBISYSTEM France
+33 (0) 233 045 000
contact@cubisystem.com

JETFLOAT International
+43 (0) 624 674 294
office@jetfloat-international.com

- Rigid aluminium pontoons
Poralu Marine
ZI rue des Bouleaux
01460 Port - France
+33 (0) 474 767 811
Dealer of SEAFLEX.
contact-marine@poralu.com

Part 5.

Glossary

Abyssal
Relating to the region of the ocean bottom between the bathyal and hadal zones, from depths of approximately 3,000 to 6,000 meters (10,000 to 20,000 feet).

Anchor ring
Heavy duty ring, eye loop or bail made out of metal.

Baring
Distance betwenn a rhizome (equivalent of the stem for the Posidonia) and the substrate. The increase of the baring is generally due to a shortage of sediments. Even when strongly bared, a rhizome is still alive (with shoot and leaves) if it stays fixed to a substrate by its roots.

Biocenose
A group of interacting organisms that live in a particular habitat and form an ecological community more or less stable within a defined territory.

Bio-construction
Three-dimensional structure erected by marine organisms either vegetal or animal.

Biomass
The total mass of living matter within a defined space. The value is generally expressed as units of biomass per surface unit (e.g. grams by squared meter).

Biotope
A biological area containing the defined ecological factors necessary for the normal existence of a community of organisms either animal or vegetal.

Chafing
Deterioration due to the rubbing of an element against another.

Compaction
The state of being pressed close, concentrated, firmly united. It describes the resistance of a soil to being penetrated by an object. In a soil with a low compaction level, the object will penetrate more easily than in compact soil. The level of compaction can be measured with the help of a penetrometer.

Detritivorous
Feeding diet made up of organic detritus vegetal or animal.

Endemic
Species confined to a certain region or site.

Food-web
Vegetal and animal organisms related to each other through trophic relationships (predator/prey) make up a food chain. Several food chains can be interconnected, they therefore make up a food web or trophic network.

Infralittoral
Zone between the low water of the spring tides and the lower limit of the phanerogam meadows which is also the limit for pluricellular photophilic algae (it is 15-20 m in the ocean and 30 to 40 m in the Mediterranean sea). It is colonized by organisms which require permanent immersion.

Interstitial
Relating to or situated in the small, narrow spaces between objects more or less spherical piled one on top of the other (grains of sand, gravel, stones, rocks).

Lower sublittoral (= circalittoral)
Define the underwater zone where the **only** vegetation that can develop is made of algae. It is situated between the Infralittoral zone (where phanerogam meadows develop) as the upper limit and the end of the euphotic zone as the lower limit. The depth of the lower limit depends on the turbidity of the water (usually 100 m, where only sciaphilic algae develop).

Mat
Monumental construction resulting from the horizontal and vertical growth of Posidonia rhizomes with entangled rhizomes, roots and particles of sediments trapped in.

Mediolittoral
Zone of the coastal space situated between the highest high tides and the lowest low tides.

Meiobenthos
Group of Metazoa that can pass through a mesh of 500 micrometers but will be retained by a mesh of between 100 to 40 micrometers.

Natural heritage
The natural heritage can be considered as the biodiversity upon which man has an impact by transforming it, exploiting it, (in the sense of using up a ressource), conserving it, restoring it and giving thereafter an economical, ecological, socio-cultural, and even ethical value.

Nursery
Area where juvelines or young invidiuals find the micro-habitat required for their development into the sub-adult stage.

Organogenic debris
Debris of organic origin, that is to say biological structures built by animals (tests, urchin needles, mollusks shells, fragments of skeletons of bryosoans or cnidarians)or vegetals (calcareous thallus).

Phanerogam
A plant that has roots, branches and leaves and has a sexual reproduction by flower and seeds. In the coastal Mediterranean area there are some marine phanerogams living in the shallows (needing light for photosynthesis) Zostera, Cymodocea, Posidonia.

Photophilic
Characterize the organisms which require or are able to withstand strong light.
Antonym : sciaphilic

Penetrometer
Tool used to measure by penetration the level of consistency or resistance of a sediment sample.

Production
In ecology, it means the quantity of living matter (organic matter) created by a link of the food chain per unit of time, of surface or of volume. There is a distinction between the primary production (vegetal) and secondary production (animal)

Recruitment
Process htrough which the youngest fraction of the population integrates for the first time the groups of adult and sub-adult fishes. This recruitment usually results in a change of habitats (from open water toward the seafloor). For fishing specialists it is the fraction of the youngest fishes which becomes accessible for exploitation.

Sciaphilic
Characterize the organisms which are not able to withstand strong light.
Antonym : photophylic

Scouring effect
Digging of the sediment, erosion by hydraulique action (the force of moving water: currents, whirlpools, swirling).

Sessile
Living organism fixed to a solid substrate.
Antonym : vagile

Specific diversity
Value related to the number of species present in an environment or a given site. Several parameters have been developped to measure this diversity but the most straight forward remains the number of species.

Specific richness
See specific diversity.

Screw torque
Two forces, parallel, equal and of opposite direction. The forces acting in opposite directions at the extremities of a lever.

Spawning area
Place where several individuals of the same species come together to reproduce by emmission of their gamets in open water. Generally, the gathering together for spawning hapens after animals have come to the site from places near or far.

Supralittoral
Coastal zone just above high water of spring tides. The Supralittoral zone (splash zone, sometimes also referred to as the white zone) outlines the stretch above the high water level. The width of this zone changes with the slope of the shore, variations in light and shade, exposure to waves and spray, tidal range.

Tidal range
The periodic variation in the surface level of the oceans and of bays, gulfs, inlets, and estuaries, caused by gravitational attraction of the moon and sun.

Trenching
Act of burying into the seafloor after digging a trench. It is used for a boat or an object (cable, etc.) sank to the bottom and situated in a depression (natural or artificial) in the sediment. It is also used for solid blocks resting on the seafloor.

Vagile
Living organism capable of movement on the seafloor (walk, crawl, jump, etc.) or of swimming.
Antonym : sessile

Vane tester
Tool used to determine the resistance to shearing of fine soils.

Part 6.

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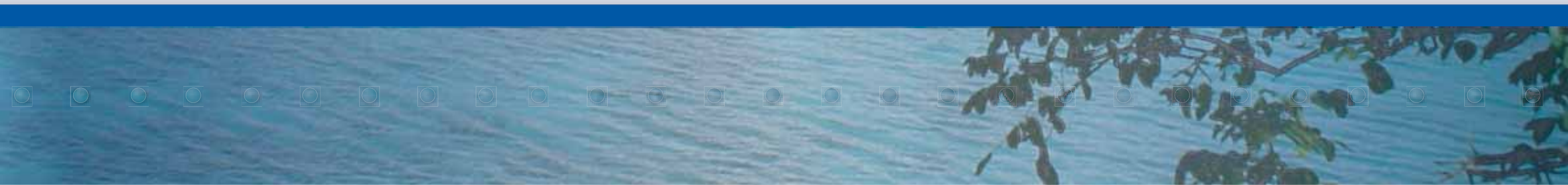

Qu'est-ce que le réseau MedPAN ?

MedPAN est le réseau des gestionnaires d'aires marines protégées de Méditerranée.

Ce projet d'une durée de trois ans (2005 - 2007) est financé par l'initiative Interreg IIIC zone Sud. Il rassemble 23 partenaires de 11 pays du pourtour méditerranéen, dont 14 partenaires européens (France, Italie, Grèce, Espagne, Malte, Slovénie) et 9 partenaires de pays non européens (Maroc, Tunisie, Algérie, Croatie, Turquie).

Ces partenaires gèrent plus de 20 aires marines protégées et travaillent la création de plusieurs sites.

Le réseau a pour objectif de faciliter les échanges entre aires marines protégées méditerranéennes afin d'améliorer l'efficacité de la gestion de ces territoires.

En particulier, le réseau permet de :

- promouvoir le partage d'expériences et de bonnes pratiques entre gestionnaires ;
- proposer des solutions aux problèmes de gestion des aires marines protégées ;
- améliorer les compétences des gestionnaires ;
- faire connaître le rôle des aires marines protégées et favoriser leur reconnaissance ;
- diffuser des messages communs à l'ensemble des aires marines protégées.

Le réseau organise plusieurs ateliers thématiques chaque année sur des problématiques de gestion communes à l'ensemble des aires marines protégées.

Le réseau finance la réalisation d'études.

Le réseau a pour vocation de produire des outils méthodologiques destinés à aider les gestionnaires dans leur travail quotidien.

Le réseau publie également le Répertoire global des aires marines protégées de Méditerranée.

What is the MedPAN network?

MedPAN is the network of managers of marine protected areas in the Mediterranean.

This three-year project (2005 - 2007) is funded by the Interreg IIIC zone South initiative. It brings together 23 partners from 11 countries around the shores of the Mediterranean, of which 14 partners are European (France Italy, Greece, Malta, Slovenia, Spain) and 9 partners from non-European countries (Morocco, Tunisia, Algeria, Croatia, Turkey).

These partners manage more than 20 marine protected areas and are working towards the creation of several new sites.

The aim of the network is to facilitate exchange between Mediterranean marine protected areas in order to improve the efficiency of the management of these areas.

Specifically, the network can :

- promote the sharing of experiences and good practices amongst managers ;
- suggest solutions to management problems of marine protected areas ;
- improve the capacity of managers ;
- make the role of marine protected areas known and encourage their recognition ;
- disseminate messages common to all marine protected areas.

The network organizes several thematic workshops each year on management issues common to all the marine protected areas.

The network finances the carrying out of studies .

The purpose of the network is to produce methodological tools designed to help managers in their daily work.

The network also publishes the Global director y of marine protected areas in the Mediterranean.

www.medpan.org

Le réseau MedPAN est coordonné par le WWF-France
The MedPAN network is coordinated by WWF-France

pour une planète vivante*

* for a living planet*