MedPAN COLLECTION

Snorkel surveys of the marine environment

Methodology guide

Parc national des Calanques

Conservatoire d'espaces naturels Provence-Alpes-Côte d'Azur

GIS Posidonie

Agence des aires marines protégées

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Publication lead

Parc national des Calanques

The Calanques national Park is the 10th French national park and was established on 18 April 2012 by a decree of the Prime Minister. At the gates of a city of nearly one million inhabitants, it is the first in Europe to include terrestrial, marine and suburban areas. Its core area covers 8,500 ha of spread over three municipalities and 43,500 ha of sea. Its main missions are to reconcile the preservation of the natural and cultural heritage of the area with human activities.; to welcome, inform and educate the public; to fight against pollution on land and at sea.

This guide is the product of a small project funded by MedPAN in 2013 that was led by the Conservatoire d'Espaces Naturels of the Provences-Alpes-Côte d'Azur region that was then in charge of the management of the Frioul archipelago Maritime Park which is now entrusted to the Calanques national Park.

> > www.calanques-parcnational.fr/

Technical partners

GIS Posidonie

GIS Posidonie is an association bringing together Mediterranean universities and managers. It aims to study, protect, restore, manage, inform and raise awareness about the marine environment, and particularly on Posidonia meadows. It was created in 1982 at the initiative of the French Ministry of the Environment and the National Park of Port-Cros. Its activities are developed around four main areas: basic and applied research in marine ecology, coordination of research programs, expertise and environmental consulting and the publishing of scientific and general public works. GIS Posidonie coordinates Posidonia meadows surveillance systems at regional and local level. It operates in the Mediterranean protected sites: National Park of Port-Cros, the reserves of Corsica (France), the National Park Zembra and Ichkeul (Tunisia), the El Kala National Park (Algeria). It performs fauna and flora inventories, mapping of populations, ecosystem studies and participates in the implementation of the key axes of the installation and management. GIS Posidonie is based in Marseille, Nice and Corte.

> > http://mio.pytheas.univ-amu.fr/gisposidonie/

Agence des aires marines protégées

The Agence des aires marines protégées is a public undertaking created by the law of 14 April 2006 and placed under the governance of the Ministry of Ecology, Sustainable Development and Energy. The main missions of the Agence des aires marines protégées are : supporting public policies for the creation and management of marine protected areas in all French waters, running the MPA network, providing technical and financial support to marine nature parks, and strengthening French potential in international negotiations concerning the sea.

The Agence des aires marines protégées has today been integrated to the newly formed Agence Française de la Biodiversité.

> > www.afbiodiversite.fr

Financial partners

French Global Environmental Facility

Working to support French cooperation and development policy for global environmental protection, the French Global Environmental Facility (FGEF) provides grants to sustainable development projects in areas relevant to the multilateral agreements on the environment signed by France. The FGEF is an instrument of French cooperation and development policy in the areas of climate change, biodiversity, international waters, land degradation (including desertification and deforestation), persistent organic pollutants and protection of the ozone layer.

> > www.ffem.fr

MAVA Foundation

Dr Luc Hoffmann established MAVA in 1994 as an expression of his long personal commitment to conservation. MAVA is a family-led, Swiss-based philanthropic foundation with an exclusive focus on the conservation of biodiversity. Its focal regions are the Alpine Arc and Switzerland, the Mediterranean Basin and Coastal West Africa.

> > fr.MAVA-foundation.org

Prince Albert II of Monaco Foundation

In June 2006, HSH Prince Albert II of Monaco decided to establish his Foundation to address our planet's alarming environmental situation. The Prince Albert II of Monaco Foundation is dedicated to the protection of the environment and the promotion of sustainable development on a global scale. The Foundation supports initiatives taken by public and private organizations, in the fields of research and studies, technological innovation and socially-aware practices.

> > www.fpa2.com

Région Sud

The Région Sud (France) is an elected assembly which manages and exercises powers over its territory particularly in economic and sustainable development matters. The Region is a key partner in projects that contribute both to environmental protection and economic development.It also supports projects that involve the Mediterranean as a whole, assisting economic stakeholders and associations either financially or by providing logistics and technical skills

> > www.maregionsud.fr

City of Marseille

The city of Marseille has been supporting the activities of the MedPAN network since 2010.

> > www.marseille.fr

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Introduction

The manager of a Marine Protected Area (MPA) must find the right balance between the preservation of species and habitats and the sustainable development of human activities by taking into account the natural evolution of the ecosystems.

Basing himself on the identification of issues, the definition of assumptions and the preservation objectives of the natural heritage, the manager develops a management plan which sets out management actions. He directs and adjusts the management policy from studies and follow-ups based on the conservation status of species and habitats as well as the socio-economic context.

In this paper we are going to focus on the characteristics of the monitoring of our marine natural heritage.

Two correlative levels can be perceived in studying species and habitats:

- Ad hoc scientific studies: these are specialised, comprehensive and are used to study a wide range of species and help to refine our knowledge on our marine natural heritage using a complex and sometimes expensive methodology,
- Scientific monitoring: this has a simple methodology which is standardised and scientifically endorsed as well as being easily mobilised and cheap. The implementation of this kind of monitoring can meet an initial hypothesis, but often leads to identifying new questions which lead to the implementation of further/new ad hoc and specific studies.

Long-term monitoring protocols can be defined by carrying out inventories and detailed studies beforehand.

A manager is the ideal person to implement long-term monitoring because he is on hand on a daily basis leading management, surveillance, information and raising awareness actions. These monitoring tools will allow him to adjust management actions and initiate new, more in-depth studies adapted to his needs. Ad hoc and specific studies can be done internally depending on skills, human and equipment resources available or outsourced to a specialised scientific team.

In situ observation of the underwater environment requires specific scuba diving equipment. However, for shallow coastal waters a number of monitoring activities can be done using simple and compact equipment: fins, mask and snorkel.

There are many benefits in using this type of method such as equipment costs, mobilisation time, time spent on the ground, the surface area covered and an easy communication between participants. We do not wish to set a depth limit for this method; however it seems obvious that the deeper one dives the more difficult it would become to implement a protocol. On top of this, there would be the observer effect dreaded by any naturalist observer. The scuba diving equipment is essential once one goes down to depths > 5 m. These two techniques are complementary when studying the marine environment.

We suggest in this guide a collection of simple methodological monitoring methods which a manager can put in place internally and with the use of snorkelling. Firstly, we will present the role of natural monitoring within the MPA's management plan and the specifics of snorkelling with the equipment, free-diving methods and safety guidelines. Then six methodological notes illustrating how monitoring the mid and upper infra-Mediterranean coast's species and marine habitats will give field protocols; ways of using the data will also be mentioned. Finally, we will discuss five other methods where snorkel surveys were used to monitor several MPAs.

All these methods must be adapted to each MPA's specificities and problems. It would also be advisable to consult scientists on how to apply the protocols.

This document is the first step in achieving a methodological compilation and is not complete as species, habitats and management issues differ from one corner of the Mediterranean to the other. The idea is to introduce a collaborative approach within the managers' network (MedPAN and French MPA Agency) so that this work can be enriched by each MPA's expertise.

1. Prerequisites to implement a monitoring protocol

1.1 A few definitions and precautions

The naturalistic approach

The naturalistic approach is essential in managing a natural area and allows the manager to intuitively perceive the changes in the state of conservation of the natural heritage. These intuitions are confirmed or refuted by rigorous monitoring. The manager develops his sense of observation by being regularly on the ground enabling him to ensure that there is an effective environmental monitoring.

To this end, it is important that observers gain experience before implementing monitoring. In fact, a protocol's results can be biased by the observers' ability and knowledge. (Besnard A., J. M. Salles, 2010).

Inventories and monitoring

A naturalist survey provides an inventory at any given time whilst monitoring is part of a regular surveying process over the medium to long term (Besnard A., Salles JM, 2010). For specific problems or questions, monitoring must help to assess (Fiers V. *et al.*, 2003.):

- the natural dynamics of the environment,
- its evolution linked directly to management actions,
- the emergence of new constraints, mainly anthropogenic which are likely to interfere with the site's natural functioning.

When implementing monitoring, it is important to control the bias so as to ensure reliable and robust results and that the data analysis over time is relevant (Besnard A., Salles JM, 2010). To achieve this objective a strict protocol defining a precise sampling strategy is necessary.

A sampling strategy

Defining a sampling strategy is a prerequisite when implementing monitoring.

A sampling strategy enables to identify and define: (1) the biological equipment choice (usually linked to the initial problem, but it often requires refining), (2) the equipment and human resources, (3) the timing and frequency of data collection, (4) the number and distribution area of observation stations or sample sites. It is important to take into account the previous use of the results when organising the planning and setting up a provisional budget.

During the development of a sampling strategy, it is important to think about the transcription of the data collection (Fiers V. *et al.*, 2003). A good understanding of the time period and frequency of field campaigns as well as the equipment and human resources that are regularly available as well as over the long term will ensure rigorous data collection over time.

It is rarely possible to ensure a comprehensive survey in a MPA (technical and financial constraints), so sampling is important to study species and habitats via statistical methods. One must identify a set of small areas which represent the geographical, ecological and regulatory diversity of the MPA. These small areas called sub-units or stations make up the sample (Besnard A., Salles JM, 2010). Two major types of sampling exist: random or systematic with several sampling methods within them (simple, stratified, transect, time tracking etc.). The theoretical concepts of these sampling plans have been developed by several authors (e.g. Frontier, S. 1983, Scherrer, B. 1984 A. Besnard, JM Salles, 2010).

For time tracking surveys, we recommend to keep the same stations in each period, even if statistically the most rigorous method consists in studying the stations by drawing randomly each field campaign.

Developing a sampling strategy is complex, particularly regarding the choice and the distribution of sampling stations, a consultation with the scientific community is thus strongly recommended.

1.2 What is the purpose of monitoring?

In a MPA management process, there are a series of key steps to be taken. Monitoring is important in two of these steps. They create a standardised repetition of data collection over time and are tool for decision-making within the management actions' programming.

Monitoring makes it possible to either respond to a questioning on management evaluations or to ensure an environmental watch (Figure 1).

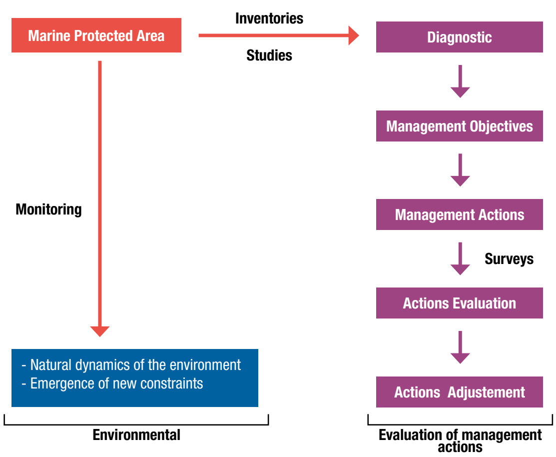

Figure 1: Surveys as a tool for decision-making

2. Snorkelling in the framework of the management of an MPA

2.1 The choice of snorkelling equipment

Using snorkelling to carry out naturalist monitoring requires specific equipment: a wetsuit, a pair of fins, boots, a mask, a snorkel and a weight belt. The diver's equipment must allow him to move freely in order to facilitate naturalistic observations and implement protocols.

The wetsuit

The choice of a wetsuit should be based on the following criteria:

- the budget available,
- the intended use,
- when and where will diving take place.

A wetsuit protects the diver from heat loss linked to the aquatic environment, but also protects him from the marine environment (rocks, animals which sting etc.). In the Mediterranean, the temperature conditions vary greatly from one region to another, as well as from one season to another. For example, in Marseille temperatures vary from 11°C in winter to 24°C in the summer.

For naturalistic monitoring, the wetsuit's versatility and flexibility is important as it will sometimes only be used on the surface (without immersion) and sometimes with immersion. The wetsuit should facilitate:

- prospection (the head and neck can move freely)
- the ability to do many bust and arm movements,
- swimming (large distances can be covered)

Even if you already have wetsuits for scuba diving, it is recommended for snorkel surveys to have an underwater fishing wetsuit which will be more flexible, warmer despite having the same thickness and therefore more suitable (Figure 2).

Figure 2: 2-piece wetsuit for underwater fishing

It is recommended to have wetsuits of different thicknesses (3 mm, 5 mm and 7 mm) in order to adapt to temperature conditions. The ideal wetsuit is the thinnest one possible so as to gain in flexibility and in ballast. The thicker the wetsuit, the more weights are needed to cancel out its buoyancy.

For naturalistic monitoring, protocols defines the equipment that accompanies the diver. Therefore, it is important to not be over equipped and to adapt the wetsuit's thickness in order to reduce as much as possible the lead weights. In addition, having several wetsuits means the equipment will last longer.

However, the cost of a wetsuit is significant! It is possible to have a just one thickness: 5mm being the most versatile (Table 1). This thickness means one can work in 11° water temperatures while still remaining energetic; but it would be difficult to spend over an hour in the water. It is possible to mix and match with a jacket which is thicker than the trousers.

Thickness	Cold water (11° to 14°)	Average (15° to 18°)	Hot water (19° to >22°)	Mobility
3 mm	+	++	+++	+++
5 mm	++	+++	++	++
7 mm	+++	++	+	+

Table 1: Versatility provided by wetsuit's with different thicknesses

For the type of material, there are two types: smooth neoprene (or split) or jersey neoprene (Figure 3).

Figure 3: On the left: a smooth neoprene jacket (split) and on the right a jersey neoprene

We recommend that the inside of the wetsuit is made out of smooth neoprene (or split) as it fits the body and skin perfectly. However, this material is more fragile than jersey so it is important to put the wetsuit on carefully, and it is imperative to use soapy water or talc.

As for the wetsuit's exterior, there is a choice between smooth neoprene and neoprene jersey. The smooth neoprene ensures a better water entry, but is a fragile material which is not suitable for naturalist monitoring as it can tear when in contact with the natural environment or equipment. Jersey is more suitable for a rocky environment and in general.

The fins and boots

In general, the fins used for free-diving and snorkelling are large for maximum comfort and provide a greater forward thrust.

For naturalist monitoring, the choice of fins depends on the following criteria (Table 2):

- propulsion efficiency,
- hindrance in shallow waters (<2m)
- versatility (with boots).

Type of fins	Propulsion	Hindrance	Versatility*	Boots
Full foot fins, large blade	+++	+++	+	Just boots
Adjustable open heel fins	+	+	+++	Low cut boots or boots
Full foot fins, medium blade	++	+	++	Just boots

*: Mobility in open water or in shallow waters, fins can easily be removed and then walk on the rocks or on the seabed, ideally boots with reinforced soles.
Table 2 : Versatility provided by the different type of fins

We advise full foot fins, which have a very good foot support, with a medium blade to avoid hindrance and fin strokes in shallow waters (Table 2, Figure 4).

With full foot fins it is impossible to wear boots, so low cut boots are needed to walk to avoid the risk of damaging the boots or be injured.

Figure 4: Medium blade full foot fins with boots and low cut boots

The advantage of adjustable open heel fins is that they can be worn with boots that enable to walk on rocks or other terrain without the risk of getting hurt (Figure 5). This alliance provides an important versatility with minimal equipment for monitoring in shallow waters.

Figure 5: Adjustable open heel fins with boots

Full foot fins with a large blade are not suitable for monitoring in shallow waters (Figure 6). You will find yourself quickly restricted in your movements. Touching the bottom is inevitable and may affect the fixed flora and fauna, raise the sediment thus obstructing field protocol.

But on the other hand, these fins are very useful for surface monitoring or surveys over long distances.

Figure 6: Long blade full foot fins with boots and low cut boots

The thickness of the neoprene fabric for the boots or low cut boots should be between 3-5 mm. Boots with jersey inside and out are the most suitable.

Gloves

The use of gloves can be inconvenient in naturalist monitoring (Figure 7), as handling the equipment requires precise movements, e.g. when using a camera or taking notes.

However, gloves make diving in cold waters more comfortable. We recommend choosing very flexible gloves with the best fit possible.. We would also recommend jersey as it is a more resistant than smooth fabric.

Figure 7 : A pair of gloves

Mask

It is best to choose a small free-diving mask as this will facilitate your free-diving because less air is needed to offset the loss of volume that occurs when you immerse yourself (Figure 8). The choice of mask should be the one which gives the best possible field of vision.

Figure 8 : The Mask

One must also check in the shop that the mask is well suited to your face; it must be able to stay on, without the strap's support, after putting slight pressure on with your hand.

Do not forget to grease a new mask (washing-up liquid, toothpaste or another degreaser) before diving to prevent it fogging up.

Snorkel

One must choose a snorkel with a relatively large diameter, so that ventilation is not impeded. The mouthpiece (silicone or rubber) should be comfortable and well suited to the mouth (Figure 9). It should be easily removed and put on in the water with just one hand. The snorkel should be relatively flexible so as to not to hurt you when slipped under the mask strap.

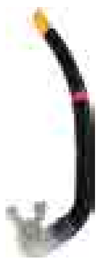

Figure 9 : The snorkel

Weight belt

A weight belt is essential when you want to dive. Even on the surface, it can slightly push the body under water which helps with fin strokes. One should count 2 kg for any bodyweight, then another 1 kg for each millimetre of the wetsuit's thickness. Thus, for a 3mm wetsuit you will need 5 kg, for a 5mm wetsuit - 7 kg and for a 7mm wetsuit - 9 kg. These recommendations are a theoretical base which needs to be adapted to everyone's morphology, but also to the various protocols, especially for surface monitoring where it will be necessary to remove 1 or 2 kg in order to reduce tiredness when swimming.

Figure 10 : The harness

Several types of belts are available on the market:
- the harness,
- the belt.

The advantage of the harness is that it correctly distributes the weight all over the body and is very comfortable (Figure 10). Now there are harnesses where you can adjust the weight (neoprene harnesses where lead weights can be put in the pockets). Beware, harnesses are not easy to take off when in difficulty.

We suggest a rubber belt with a stainless steel weight clips, a "Marseillaise" belt (Figure 11). You can adjust the number of weights. This type of belt can be easily removed when necessary.

Figure 11 : The rubber belt with a stainless steel buckle

2.2 Essential information on free-diving mechanisms

Above all, we must remember that the use of snorkelling within an MPA management plan aims to study species and habitats and in no way to accomplish athletic prowesses. A diver's safety should always be more important than data collection.

Breathing

The oxygenation of body cells is achieved through breathing which leads to an exchange of oxygen - carbon dioxide.

Breathing has four steps (Dematteo A., 2006):
- ventilation (pulmonary breathing) to renew O2 and release CO2,
- the passage of gas in blood cell,
- transport of gases through the blood,
- cell's breathing during which the cell uses oxygen and releases CO2.

Free-diving

In diving, free-diving is defined as a temporary and voluntary cessation of gas exchange between the lungs and the atmosphere (A. Dematteo, 2006), in other words to stop breathing. Physiological phenomena which occur during free-diving are complex and are not the subject of this document. We will only present the sensations which are important to know about to ensure a diver's safety.

During free-diving, increasing contractions of the diaphragm occur. The sensations felt by the diver in free-diving can be summarised in two phases (Lin YC, 1987 in Dematteo A., 2006):
- Easy phase: between the beginning of free-diving and the first diaphragm contractions, the diver feels no painful contraction,
- Struggle phase: the diaphragm contractions result in a tightening of the chest causing an intense "thirst for air".

The implementation of monitoring should never encourage a diver to enter the struggle phase. Divers who reach this phase are professional free-divers who want to exceed their limits.

The signs announcing a black-out

Hypoxic black-out is: "a sudden and transient loss of knowledge, self-limiting with a rapid return to a normal state of consciousness, accompanied by a loss of postural tone. It is the consequence of a transient global cerebral ischemia "(Blanc JJ., 2006 in Dematteo, 2006).

A black-out is not serious in itself, but when it occurs at sea, it may result in drowning. It can occur underwater (usually a few meters from the surface) or on the surface even after respiratory recovery.

Table 3 below gives details on the indications, warning signs and descriptions of a black-out. This table describes the sensations that trained free-divers feel when they want to achieve a physical performance. By following a few basic rules (next paragraph), you can safely use free-diving in work and avoid any risk of black-out.

	Personal symptoms	External signs
Before free-diving	• tingling of the extremities • floating sensation • high excitement	
At depth	• unusual comfort feeling • no urge to breathe or return to the surface • feeling that returning to the surface will take a long time • panic feeling	• excessive length • abnormal restlessness or relaxation
During the ascent to the surface	• heavy or hot thigh muscles • scotoma* or restricted field of vision • protracted comfort or on the contrary abnormal hardship	• before the black-out: - release belt - rapid and disorderly unreasonable movements, , illustrating the anguish of a free-diver - anxious search of a visual aid (surface, the face of the safety diver) • during the black-out: - release of an important number of bubbles - oscillation reflex movements - stops kicking, immobile free-diver, can plummet or return to the surface according to buoyancy
On the surface	• before the black-out: - amnesia - denial of the incident	• before the black-out: - pale face - cyanosis - hypotonia or hypertonia - blank stare, not registering to the outside, panic in the eyes - twitching, jerking movements - difficulty in grasping the cable • during the black-out: - slowing or airway stopping (spontaneous respiratory recovery or after skin stimulation and / or mouth to mouth resucitation) - no initial cardiovascular arrest - tone disorders (hypo or hypertension) may precede brief tonic-clonic movements

Scotoma : refers to a deficiency in the field of vision due to a lack of perception in an area of the retina

Table 3 : Warning signs and description of hypoxic black-out in free-diving (Oliveras, 1996)

2.3 Safety principles

The use of snorkelling in the management of a marine protected area implies a compliance with safety rules set out in internal regulations and/or framed by the national labour code. Each MPA must adapt its employees working conditions in accordance with national regulations.

We will introduce below some basic rules so that field trips can be conducted safely.

Physical condition of divers

Divers must be healthy and show no permanent or temporary contra-indication to do free-diving. To ensure this, divers must undergo a regular (annual) medical examination. The organisation must have equipment in good condition and suited for each diver.

The advantage of snorkel outings is that they can be long. However, food provided must be adapted to the energy expenditure linked to the physical effort. A good diet will also help fight against the cold. It is also important to be well hydrated before and during the field trip to compensate for water loss (Heran N., 2009).

The number of divers and their behaviour

The number of divers can vary according to field protocols. However, a minimum of two divers must be respected. Divers should always be able to help each other in pairs and remain in visual contact.

In the case of free-diving: If diving is required, divers must go in one after the other and easily reach the same depth to be able to assist each other. Hyperventilation which can play a role in the onset of syncope should be avoided (A. Dematteo, 2006 N. Heran, 2009). Divers must listen to their bodies and know how to detect physiological warning signs: cramps, shortness of breath, trembling, tingling, feeling of well being, sweating, pain, thirst (Heran N., 2009). The number of free-diving sessions should not be too high. This is why divers should take turns in free-diving which will enable them to increase their recovery time between dives. They must be prohibited at all times of trying to increase their own performance.

Unlike scuba diving which places every observer on an equal footing, snorkelling uses the divers' physical abilities. These capabilities will vary depending on the day and are based on everyone's natural potential.

It must be noted that monitoring will only be valuable if the data can be compared over time. Thus, when defining a field protocol, the average divers' physical capacity must be taken into account and not just the one of high performing divers.

Weather conditions

Weather and sea conditions are essential for safety and the quality of observations. We must therefore anticipate and plan the field trip according to the weather, which must be checked right up to the start of the monitoring session. If by any chance, the weather deteriorates during a field trip, it should simply be cancelled and rescheduled later.

Marking of the intervention area

A diver swimming on the water surface cannot be easily seen and even less so in a choppy sea. It is therefore imperative that the diver moves on the surface with a regulatory signalling buoy (Figure 12). Using a raft is helpful to carry equipment and as a marker buoy (Figure 13).

Figure 12: Divers and a marker buoy

Photo 13: Raft for visibility and carrying equipment

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3. Monitoring equipment

Field equipment is essential for collecting standardised data and ranges from simple note taking equipment to more sophisticated geo-referencing equipment such as a GPS.

This equipment must be adapted specifically to the marine environment, rinsed in fresh water after each use, so that it will withstand the test of time. We will now present the equipment used in different methodology sheets.

Note taking

• The waterproof slate

Underwater note taking is done with a simple pencil and a rigid plastic PVC holder. This type of slate can be found in relevant shops, but it is usually small and relatively expensive. During monitoring, a lot of observations need to be noted down so an A4 slate or even slightly bigger is useful. These slates should be ordered from PVC plastic manufacturers who can pre-cut them to the required size. The more you order the lower the price should be. A solution could be that several MPAs order at the same time. When you contact the supplier and explain the use of these PVC slates, it is possible that they will reply that you cannot write on them. Get a sample sent to you beforehand as in most cases the pencil does adhere. To make the slate even more sticky, you can rub it with fine sandpaper or a sanding sponge. The thickness of the slate must be at least 4 mm in order to have the right rigidity. A material to avoid is plexiglass as the pencil only moderately adheres to it.

• Waterproof sheets and laminated documents

When performing monitoring, preparing a table beforehand will often help you to organise efficiently your data entry ensuring that no parameter will be forgotten. Data entry is done on one or more waterproof sheets fixed to a slate. If there is a particular observation which is not relevant to the current monitoring programme, you can still note it down on the slate.

Sheets found in shops are A4, so the waterproof slate must be slightly bigger in height and width. These sheets are soft, plastic, very strong and a pencil adheres very well to them. They can be white or transparent. It is possible to print (laser printer) on waterproof sheets, either simple tables or maps. Take care to choose the correct referenced paper, as several different kinds of quality are available and you can only print on some of them. These types of sheets can be bought from media display suppliers and generally have the following reference “weather resistant 120 µm white matt film”.

Use a 30 cm aluminium ruler (found easily in a shop selling office supplies) to fix the sheets to the slate. Attach the ruler to the slate with stainless steel bolts with butterfly nuts. The sheets will be slipped under the ruler then fixed with a ¼ turn of the wing nuts. A simple taut string at the bottom of the slate prevents the waterproof sheets from moving; the sheets will be flattened by capillary action (Figure 14 and 15).

Figure 14: Front of waterproof slate with ruler and waterproof sheet

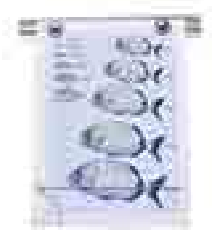


Figure 15: Back of waterproof slate with a laminated “ish silhouette” document

Laminated documents (with a classic laminator) can be attached on the other side of the slate showing a map of the area, full size fish silhouettes or anything else which is needed. Laminated documents are highly resistant to repeated submersions over time, but if you pierce them they will no longer be waterproof. This equipment can be fixed by stainless steel washers and a taut string. The advantage of a laminated document is its rigidity which makes it easier to manipulate in water. But it is not possible to write on it.

Ballasted floats

The use of weighted floats is very convenient to temporarily mark an observation (such as a pen shell) in order to take a picture or draw a map or to mark one or other study areas.

These floats can be made using compact foam that can be cut, in the shape of a pool ‘noodle’ or a fishing float for example. A 5 meter length cord can then be attached with a 150g lead fishing weight on the end (Figure 16).

Figure 16: Weighted Float

A Watch

It is important to have a watch on your snorkel outings to know the time and duration. There are specialised watches for free-diving. They can calculate instantly or retroactively the profiles of the dives made (time and depth of each dive), giving you the water temperature etc., these watches are efficient, but expensive (Figure 17). You can wear a cheap waterproof watch of your choice (Figure 18). The most important thing is that it is waterproof up to a depth of 100m to ensure its quality. Another key point is that the watch must have a "timer" function so observations can be timed. The "beep" of the timer must be relatively loud to warn you when time is up without having to keep checking it.

Figure 17: Free-diving watch

Figure 18: Cheaper waterproof watch with a timer

A Thermometer

A plastic mercury thermometer works very well and will have the relevant accuracy (figure 19).

Figure 19: A mercury thermometer

Cameras

Digital cameras now enable you to take a large number of photographs at low cost. They are now essential tools in the management of an MPA either to take aesthetic photographs to help with communicating and educating the public, to do scientific monitoring (a landscape and habitats' evolution, surfacing, etc.) or detect possible infringements.

Figure 20: Camera and its waterproof case

Light is key in photography. In an underwater environment, light decreases rapidly with depth, so it is necessary to use a wide-angle lens to counteract a long exposure. SLR cases cope perfectly with these constraints but are very expensive, the cases too. In addition, most of the colours disappear beyond a certain depth leaving the impression that everything is blue. It then becomes essential to use very expensive artificial lighting equipment which is bulky and difficult to use.

In shallow coastal waters, there are less constraints and a simple compact camera can be used, but it must have an underwater mode which can in some cases "warm" pictures and thus take high quality pictures. Get information from specialised shops or on forums, many compact cameras and bridges have proven their worth and often offer the possibility of filming in high definition. It is not necessary to buy special brand waterproof cases as generally they are more expensive. These cases (Figure 20) need careful maintenance and rigorous use to avoid your camera getting flooded which is always fatal. It is strongly recommended to test the waterproof case underwater without the camera to ensure it is waterproof. Place the camera in the waterproof case and close it before going into the field to avoid any incident.

To prevent fogging up, it is very important that your camera does not have a thermal shock. To avoid this do not put your equipment in the sun before going into the water and systematically put a bag of drying salts in the waterproof case. We suggest you equip yourself with a small rigid cooler and you can add compact foam in it or simply place the camera wrapped in a towel. Your equipment will then be well protected from the sun and from any shocks during transport.

Taking photos is much easier since the digital age; the number of pictures can quickly become substantial. It is important to anticipate archiving and develop a photographic database.

Waterproof compact cameras also exist now. They can withstand depths of 10 meters or so. The advantage of these types of cameras is that you do not have to carry around a waterproof case, so these cameras are very convenient.

A GPS

Data geo-referencing is greatly facilitated by a portable GPS. We recommend the use of a waterproof GPS receiver which has sub-meter accuracy to collect highly accurate GIS data (Figure 21). This type of device allows you to edit and easily export data (species, habitats, transects or permanent areas, macro-waste etc.) and then analyse with a Geographic Information System.

Figure 21: Waterproof mobile GPS

Even if it is waterproof, we recommend placing the GPS in a waterproof pouch when it is on the raft with you.

Permanent signalling buoys

Marking out a transect or a permanent area is possible by using geodetic buoys. These buoys are designed to be fixed in the sediment in a sustainable way using a galvanized steel fitted anchor with steel rods that hook into the ground to avoid tearing. These buoys are fixed by using a specific hammer and a mandrel (Figure 22).

Figure 22: Resin marker and the anchor fixed with the mandrel

A cheaper and sometimes more convenient method is to use steel rods as markers which you make into a U shape and fix in the sediment using a hammer.

Measuring equipment

A naturalist regularly uses measurement equipment, whether to measure a distance when marking out a transect, the depth of a creek, or to measure a marine organism. Tools can be made and calibrated according to specific needs, for example for establishing the width of an inventory corridor.

Measuring Tapes

Large measuring tapes are generally used to measure distances along a transect. We recommend the use of flexible plastic tapes on a reel (Figure 23). It could be convenient to have several lengths (10m, 20m, 30m, 50m etc.) depending on protocoles in use.

Figure 23: 50 meters measuring tape with reel

A Calliper

A calliper is very useful for taking measurements of a marine organism such as a sea urchin. We recommend you use a plastic calliper (Figure 24), whose accuracy is to the millimetre.

Figure 24: Plastic calliper

Scaled gauges

These rigid gauges will be useful to determine the width of an inventory corridor. You can make them into any specific length you need using PVC tubes. You can add your specific metric benchmarks to them using sticky coloured tape (Figure 25). Those used to seal electrical wires are perfect.

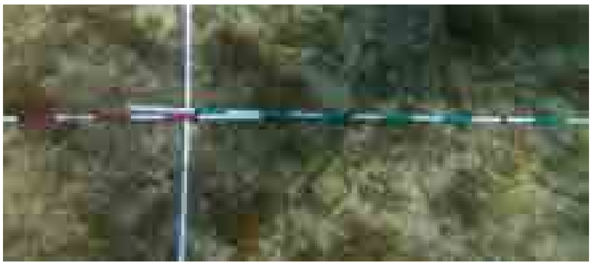


Figure 25: 2 meters scaled gauges marked every 10 cm

A measuring and weighted cord

Useful for measuring shallow water depths, attach a lead weight to the end of a string which you hold vertically to measure the depth of a creek bed. You can either compare it with a measuring tape to know the water level or mark the cord to the desired accuracy using little knots which you can colour with paint or varnish.

A Compass

The overall height of a pen shell without sediment can be easily measured using a compass; the spacing can be measured using a ruler. This tool can be easily made with two bits of wood, which will be fixed with a screw and a wing nut (Figure 26). The points of the compass are made using nails.

Figure 26: Compass

Quadras

A Quadra placed randomly or not, enables to measure a known surface area. The sizes generally range from 20 to 40 cm according to our needs. They can be made using a PVC pipe with a right-angled join (Figure 27). To make them less bulky during transport, place a bungee cord in each one so that you can undo the Quadra without separating the parts. The Quadra can be sub-divided by a bungee cord. A Quadra can also be made using a folding carpenter's ruler.

The Quadra may also include a mesh to use the contact point method (Figure 28). This mesh is made with a relatively thick nylon rope.

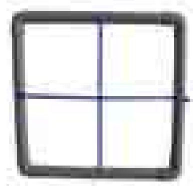


Figure 27: PVC Quadra subdivided into four 20 cm squares

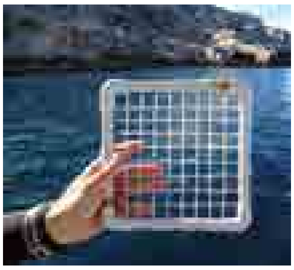


Figure 28: A 20 cm Quadra

A raft

The raft is very useful as it can hold a wide array of equipment. It can be anchored in the vicinity of a work area with a 1kg lead weight on the end of a rope (Figure 29). It is important that the raft has an alpha flag or a St. Andrew's cross or a red flag with a white diagonal to indicate the presence of divers.

Figure 29: Raft with red flag with a white diagonal

4. Methodology factsheets

Develop your naturalist culture!

Information on an observation

All naturalist observations are interesting to note down and can prove to be very useful in the long term as long as they are done rigorously. It is important to take advantage of being on the ground during the implementation of a protocol or a surveillance mission to record timely observations. Some of your observations will be on rare or rarely seen species, others common species, or singular behaviour or phenomena rarely seen like the flowering of a *Posidonia* meadow. You can also detect the presence of non-native species which will then be particularly important to monitor to assess whether they are invasive.

Develop your curiosity for naturalist observations, by trying to get and understand these observations and this will make you an effective sentinel in your MPA.

Naturalist observations made outside a formal framework must at least have the following information:

- date: eg. 3 June 2013 (possibly the time)
- location: MPA's name, location (name of a cove, for example)
- observer's name,
- species: for an observation on flora or fauna, determining the species must be accurate, otherwise it should be specified. The species must be noted down with its Latin name and the observer's name to avoid any risk of synonymy
- abundance : number of individuals if possible or covering.
- type of environment where the species was observed,
- nature of the observation: sighting, dead, failed, taken away etc.
- weather (wind strength and direction, cloud cover) and sea conditions,
- depth
- remarks: the observer can describe here the observation's important facts (e.g. atypical fish), and record his feelings!
- photos: with luck, the observations can be immortalized on a photo.

If it is a species that you do not know, try to describe the species on the spot (animal, vegetable, size, colours, behaviour, etc.) and with as accurate as possible viewing conditions so that you then try and log it when you get back to the office with guides, colleagues, networks, etc.

In addition to identifying species, a database of naturalistic observations will over time give more information on the species' biology and ecology.

As an example, here is an Excel spreadsheet with a few naturalist observations done around the Frioul islands (Figure 30).

Figure 30: "Log obs" of the Frioul islands' marine environment

Photos

Photos alone constitute a database of species and habitat and should be carefully archived. Several types of metadata come with photo files: EXIF and IPTC. EXIF data is automatically available with each new filming: shooting settings (shutter speed, aperture etc.), date and time of the photo (make sure your camera is set correctly). IPTC metadata is filled in later, with information on the author, copyright, and descriptive information (subject, keywords, etc.). This metadata can be read and updated by many image editing software.

Select one or several pictures then right click = > properties = > details (Figure 31). For the same information on multiple photos, fill the fields in batches by selecting the photos in question. Figures 32,33 et 34 refer to observations made around the Frioul archipelago (Marseille, France).

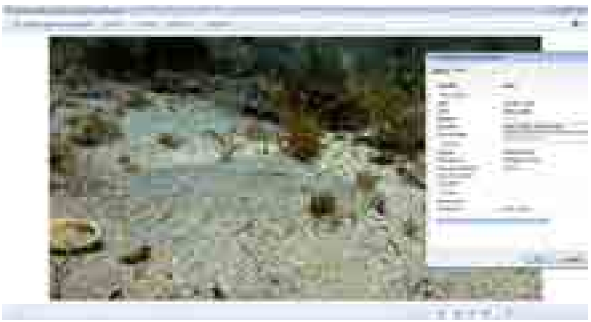


Figure 31: IPTC field information of a photograph


Figure 32: On the left *Syngnathus typhle rondeleti* observed on 30 May 2011, in the St Esteve inlet, On the right *Eriphia verrucosa* and in the foreground its moulting observed on 7 September 2013, in the Crine inlet


Figure 33: On the left *Mola mola* observed on 24 June 2009, in Marseille harbour, on the right *Tursiops truncatus* observed on 17 November 2011, in Marseille harbour


Figure 34: On the left *Sepia officinalis*, on the right *Octopus vulgaris*, both observed on 2 May 2013, in the Crine inlet

Fish visual census

Monitoring target species

Introduction

Visual counting of fish is a non-destructive technique initiated in the 1970s (Harmelin-Vivien and Harmelin, 1975) and developed in the mid-1980s (Harmelin-Vivien *et al.*, 1985) to study fish populations.

Scientific research carried out in Marine Protected Areas (MPAs) since have enabled to demonstrate the effects of protecting fish populations (eg Harmelin 1987, Garcia-Rubies and Zabala, 1990; Francour 1994; Harmelin-Vivien *et al.*, 2008). The most significant ones have been (Harmelin, 1999): (1) an increase in the diversity of species with noble species which were rare returning because they were particularly appreciated by fishermen, (2) an increase in the number of individuals (3) a return to a balanced population size structure with the presence of large individuals, (4) a change in fish behaviour with a re-colonization in shallow coastal waters due to the reduced pressure of hunting and line fishing from the water's edge.

Several studies using a visual counting method to assess the effects of protection on fish populations have highlighted the vulnerability of some species to fishing, bringing forth the concept of target species (eg Bell, 1983; Garcia - Rubies & Zabala 1990, Polunin & Roberts, 1993). The effects of fishing on fish populations is differ depending on species, particularly on shallow, rocky bottoms where several fishing methods are used, more or less selective and professional or not (Harmelin, 1999).

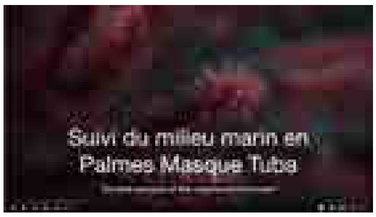
From a list of target species, the counting method described below can quantify the frequency of observing target species, the number of individuals and assessing their size. Surveys can be conducted from the surface in shallow, rocky coastal or mixed waters.

Monitoring a selection of targeted species can give information on the effects of protection, but also on fishing's impact. The determining factor is the choice of species to be monitored (Harmelin *et al.*, 1995; Harmelin, 1999).

VIDEO TUTORIALS

This methodological factsheet is also available as a video tutorial produced by MedPAN and available on youtube.

Start by watching the introduction video "Snorkel surveys of the marine environment" before moving on to the actual factsheet tutorial. Two other factsheets of this guide are also illustrated with video tutorials



https://youtu.be/x08q7Z7Jklk

https://youtu.be/o9mu5lHNzgo

Equipment and methods

The selection of target species

A prerequisite for developing a list of target species is a knowledge on the fishing activities in an MPA. No list is given here because in fact the choice depends on the taxonomic characteristics of each part of the Mediterranean basin. The choice of species will be done in coordination with the Marine Protected Areas and scientists who know the area. This choice will be facilitated if a study of fish populations has already been done.

The number of species on the list is usually limited to between 10 and 15 species but can reach 25 species depending on the agent ability to detect and identify species.

The list of selected target species of the MPA of La Galite, is presented below (Table 4) as an example.

Diplodus sargus	Sea bream
Diplodus puntazzo	Sharpnout Seabream_
Diplodus vulgaris	Two banded_Seabream
Dentex dentx	Denti*
Spondyliosoma cantharus	Cantharus*
Labrus merula	Brown Wrasse
Labrus viridis	Green Wrasse
Sciaena umbra	Brown meagre
Epinephelus marginatus	Dusky grouper
Epinephelus costae	Gag grouper *
Mycteroperca rubra	Royal Grouper
Seriola demerlii	Kingfish *

Table 4 : List of selected target species for counting by snorkel surveys in La Galite (Ody D., *et al*., 2010).
*: Currently rare species

Some criteria must be taken into account:

- Do not choose strictly cryptic species (*Murena helena*, *Conger conger*, etc.) as they are visually inaccessible,
- Do not choose species whose identification could be ambiguous,
- Do not forget momentarily rare or absent species which could be seen again thanks to the protection being put in place.

The inventory corridor

To assess the abundance of target species (no. individuals per unit area), counting will be done on a standard sampling unit (Harmelin-Vivien *et al.*, 1985). This will make it possible to compare counting stations over time and space. It is best to choose relatively small counting surface areas and multiplying the counts to help with the statistical analysis (Ody D., *et al.*, 2010).

We recommend a length of 30 metres for counting. It is possible to refer to timed runs to avoid measuring transects systematically and thus reducing the protocol. We found that 30 meters can be done in just 3 minutes.

It is imperative to adopt a slow and steady swim to keep an identical transect length to each replica. We recommend the use of a watch with an audible timer, so that without looking at the watch you know when the time is up. Other than free-diving watches, there are cheap waterproof watches with this function (see equipment).

The transect width must be set according to the general visibility conditions in the MPA. In an MPA with very clear waters, this width can be set at 6 metres, the maximum being 8 metres. Let's point out that MPAs using this method recommend 4 to 5 meters corridors. Once determined and measured, the transect's width is visually assessed at each transect.

Depthwise, surveys can be conducted at depths of between 0 and 8 metres, with 8 metres being the recommended maximum. The identification and observation of certain fish from the surface can in fact become complicated from a certain depth (absorption of colours, less visible livrée).

We will see in Section 3 how to:

- Determine transect widths,
- Train to perform timed trips.

Visual counts made from the surface

Visual counting by snorkelling can only be done from the surface. Free-diving on the bottom is strongly discouraged to avoid sampling bias (influence on fish behaviour, concentration during counting, variable divers' physical capacity). Exceptionally, a short free-diving can be done to identify an unknown species. But then the free-diving time will need to be added to the general time to keep a constant sample surface area.

Assessing the size of individuals:

Assessing the size of a fish is not easy and requires training. The estimated size is the total length and not to the caudal peduncle. The fish's measurement will be assessed by size group; an accuracy of up to 2 cm can be obtained during the training phases.

Figure 36: Harmelin J. G., 2013. Fish visual counting training. Oran, Habibas -Cap Blanc, 1st-6th June 2013

To assess the size of a fish, several tools can be used:

- the ruler set on the waterproof slate is a good indicator even if the fish is a bit far away,
- a waterproof sheet with the fish's full length silhouette gives very valuable and often essential benchmarks,
- the space between your thumb and index is a fixed length that can be helpful,
- evaluation exercises during training (paragraph 3).

Figure 37: "Note taking" side of the waterproof slate

Figure 38: "Full length silhouette" side of the waterproof slate

Counting the number of individuals:

Counting is easily done for groups of up to 30 individuals. Over this, you can use grouped classes (Harmelin-Vivien et Harmelin, 1975):

- 31 to 50 individuals
- 51 to 100 individuals
- 101 to 200 individuals
- 201 to 500 individuals

When using this data, the median of each class can then be taken. Once you are experienced in counting, you will be able to count the fish more precisely without referring to the class groups.

Figure 39: Counting and assessing the fish size becomes more complicated when the number of individuals are multiplied

Fish behaviour description

Fish behaviour will be evaluated so as to better characterise the studied site and the pressure from underwater fishing. In fact, underwater fishing is a technique where the fisherman sees the fish and stays at a safe distance (Ody D., *et al.*, 2010). In a protected area, the fish will have a more indifferent behaviour to the diver's approach.

At each station and at the end of each transect, one can note down for each species if the fish is:

- 1: very evasive,
- 2: fleeing,
- 3: indifferent,
- 4: curious.

Additional Information to collect

The presence of the species studied will partly be influenced by various factors that should be noted in each counting operation in order to clarify the interpretation results.

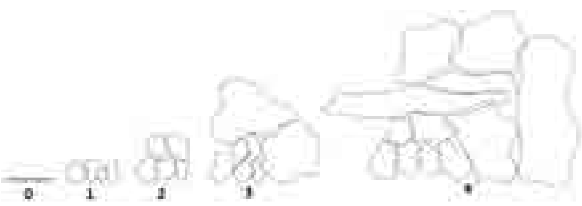
Thus, the date, the count's time slot, the water temperature and habitat are all factors that influence the fish presence. The weather (sunny, cloudy, rainy), the wind (Beaufort scale and direction), the sea's state (calm, a little rough, rough), the visibility and depth will influence the quality of the observations.

The habitat's description will be done as follows for each transect:

- percentage of sand / gravel / pebbles,
- percentage of *Posidonia* meadow,
- percentage of rock.

For the rock area, its roughness needs to be given. By roughness we mean: the physical structure of the rocky habitat which becomes more complex when it is larger and the number of crevices increases.

In this situation we propose a scale of 0-4 as in the figure below:



0: flat rock,
1: small scattered blocks,
2 small raised blocks,
3: some small and big blocks,
4: some small and big blocks forming a large area with a complex of faults, crevices and maximum overhangs (a unique rocky habitat!).

Figure 40: Roughness Scale

An example of information collected on the waterproof slate to describe the habitat along a transect:

20PM 80R / 3

This means that: 20% of the bottom is *Posidonia* meadow, 80% of bedrock whose roughness is 3.

The depth will be assessed for each transect while visibility is valid for a station on a given date.

These two parameters will be evaluated according to the following classes:

Depth (scale from 1 to 4)	Visibility (scale 1 to 3)
0 to 2 metres	visibility < 5 metres
2 to 4 metres	5 meters < visibility < 10 metres
4 to 6 metres	visibility > 10 metres
6 to 8 metres	

Preparing the waterproof slates

To facilitate note taking, we recommend that you prepare a table in which all the information will be written down. This table will help with proof-reading and data entry once back on land. The columns correspond to transect and the lines to target species. As detailed in the section on equipment, we recommend the use of waterproof sheets fixed to the slate with a ruler. Thus, you can prepare several sheets. Prepare as many lines as target species and write the name of each species. To easily identify them, divide the species per family and keep the same order.

Date:		Weather:		Wind:	Start time:	Station:
Visibility:		Sea:		Water T°C:	End time:	
Transect n°	1	2	3	…	Behaviour	
Habitat						
Depth						
Diplodus sargus						
Diplodus puntazzo						
Diplodus vulgaris						
Dentex dentex						
Spondyliosoma cantharus						
Labrus merula						
Labrus viridis						
Sciaena umbra						
Epinephelus marginatus						
Epinephelus costae						
Mycteroperca rubra						
Seriola demerlii						

Table 5: Example of a field table with the La Galite MPA target species list

Sampling

It is not feasible to propose a common sampling programme to several MPAs because they are directly linked to the feasible sampling intensity (human resources and time available) to the questions, the issues and management guidelines.

However, we recommend spreading out sampling evenly within the MPA thus ensuring that all the major sectors are covered. This does not mean an exhaustive tour of all shallow areas, but a homogeneous distribution of sampling stations in every major sector in terms of geography and regulation (Figure 41).

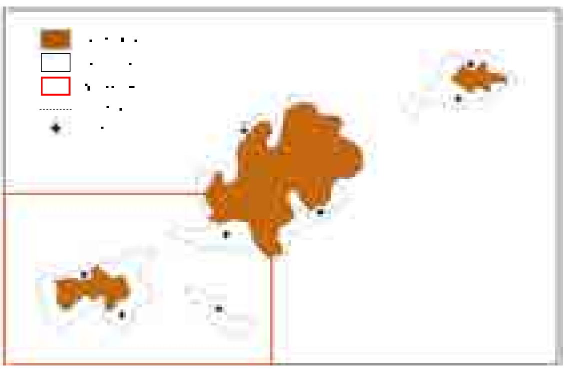


Figure 41: Distribution of sampling stations within a theoretical MPA

Transects will be randomly duplicated at least 10 times within each sampling station. Stations must be located on small rocky or mixed depths which are large enough to do replicas and get unrelated samples (Daniel B., *et al.*, 2002). Temporal replicas help to clarify the data's representativeness.

The depth should be as constant as possible on the same transect.

Depending on bathymetry, transects will be worked in parallel (depth increasing rapidly) or perpendicularly (long shallow, depths) to the coast.

For annualor multi-annual monitoring, late summer and early autumn is generally the best time of year.

Weather conditions for sampling

Sampling must be conducted in good weather and sea conditions to ensure the best possible visibility and the divers' safety. The dive must be postponed if poor visibility means that the width of the inventory corridor cannot be respected.

We recommend that two station observers do the sampling so that they can help each other in case of trouble. This will mean a station can be sampled quicker. However, be sure to maintain a good distance to ensure unrelated samples.

Use of data

Entering data

Once back at the office, it is time to enter and store the data. You can keep waterproof sheets, which provide a valuable backup in case of computer problems. It is important to enter data quickly after the field campaign, as observations are still fresh in your mind which can sometimes help when entering data. Data entry should be on an Excel spreadsheet. The most useful is a Management System Database (Access® Type).

Be careful not to enter your data as results, as this will prevent any further exploitation. Enter different information in columns as per the Protocol; the lines correspond to each new data. You will need to re-enter common data for each station on every line as well as those common to a transect even if this is tedious (Figure 42). To avoid any risk of error input, we recommend the use of dropdown lists for fields: weather, sea, visibility, species, number and behaviour.

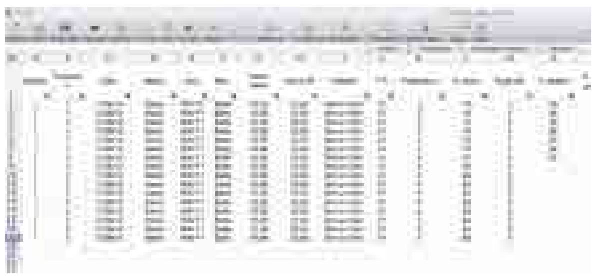


Figure 42: File Input spreadsheet

The data presented in the Excel® spreadsheet above are not from any field observations and are only shown as an example.

An analysis can then be done in Excel® using a "Pivot" table.

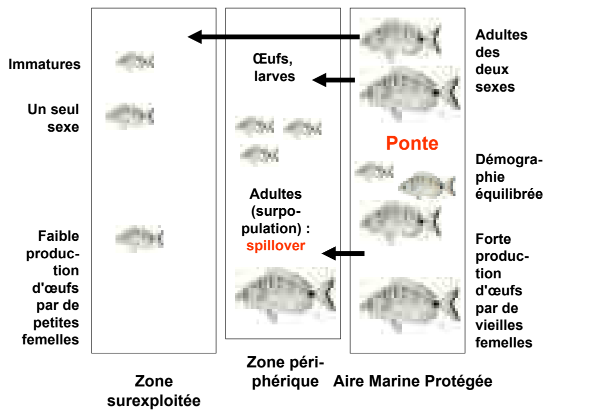
Some ideas to enhance your data

Here are some lessons (Table 6) that can be drawn from the data set. Again, it will be up to every manager to direct the sampling according to his own questioning and the management issues faced.

In each case, it will be necessary to compare each station especially when they are differently managed areas (protected area vs fishing zone). Moreover, it is possible to monitor the fish population over a length of time, which will be particularly interesting once protection has been put in place. The effects of protection, also called "reserve effect", have been studied in and around many MPAs, refer to Figure 43.

Species approach	Percentage of target species observed of all sizes (Harmelin, 1999)
	Percentage of target species observed when only considering large individuals (Harmelin, 1999)
Abundance of individuals	Total number of individuals per species of all sizes per unit area
	Proportion of large individuals per species (Harmelin, 1995)
Demographic approach	Population structure by species: number of total individuals per size group (Harmelin, 1995)

Table 6: Example of data enhancement to highlight a reserve effect



BOUDOURESQUE C.F., CADIOU G., LE DIRÉAC'H L., 2005. Marine protected areas : a tool for coastal areas management. E. Levner et al. (eds.). Strategic management of marine ecosystems, Springer publ., 29-52

Figure 43: The expected effects from the protection of fish populations

Training exercises and prerequisites

Calibration of an inventory corridor

To identify and measure the area of a corridor in your MPA, you can proceed as follows: first drop a 30 m tape measurer on the bottom. Then place ballasted floats on either side of the measuring tape. Put them at equal width distance from the measuring tape to obtain a reasonable corridor for fish identification. Finally, measure the width of the corridor using a second tape measurer. This corridor will be then visually assessed for each transect. You can train yourself to see the corridor using a marking method by placing weighted floats on either side of your tape measurer. Swim down it slowly and regularly so that you cover the distance in 3 min.

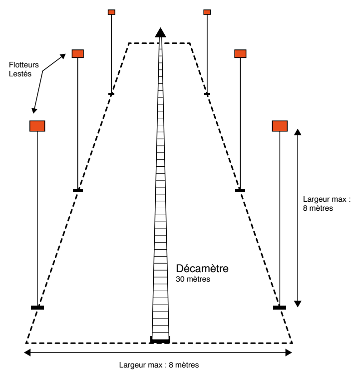


Figure 44: Marked inventory corridor

This marking is valid only for calibration training of a sample surface area. Setting up markings is not possible during sampling because it could influence the fish behaviour and therefore give a bias to the observations. Once this training is complete you can test your ability to travel 30 meters in 3 minutes by swimming along an unmarked path which you measure once finished.

Assessing the size of an individual

To obtain an accuracy of up to 2 cm, it is necessary to train yourself using silhouettes or objects of different sizes which correspond to standard body shapes (fusiforme, oblong, serpentiforme) and put them on the bottom and at different distances.

Alternatively, you can train yourself by spotting the space taken on the bottom by a fish you want to measure. The mullet is a species that is well suited to this exercise. Take physical markers at its snout and tail and then measure the distance between these markers with a waterproof slate (Figure 45).

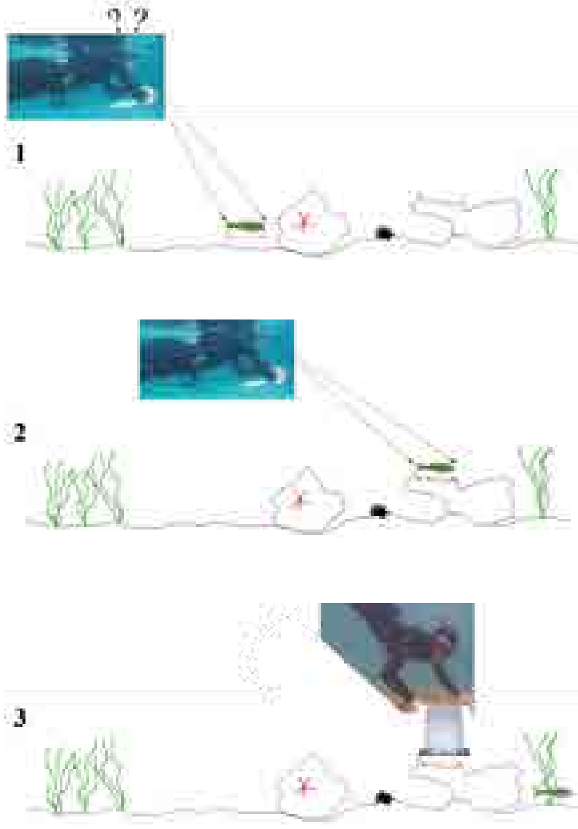


Figure 45: Evaluation exercise for measuring the size of fish

While snorkelling, communication is very easy on the surface, so do not hesitate to share and compare your observations (size and number of individuals, roughness assessment, etc.). Training in pairs or small groups is essential at the beginning of each new field season to rank observations.

Figure 46: Divers working a transect in pairs

Figure 47: Divers comparing their observations

Identifying species

Before any sampling session, field workers must learn to recognise the target species selected for monitoring. There are several marine fish identification guides, beware of the guides which only use photos. To identify a fish it is important that the photo is accompanied by a drawing and information describing the distribution and lifecycle of the species. Here are some reliable references:

- Identification Guide of Mediterranean and European fish, Patrick LYESSY 2002
- Mediterranean Fish, Jean Georges HARMELIN, Sandrine RUITTON, 2013,
- FAO Species Identification Guide (http://www.fao.org/docrep/009/x0170f/x0170f00.HTM)

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Settlement of *Diplodus spp.* on rocky shores:

Identifying and mapping nurseries, annual settlement evaluation

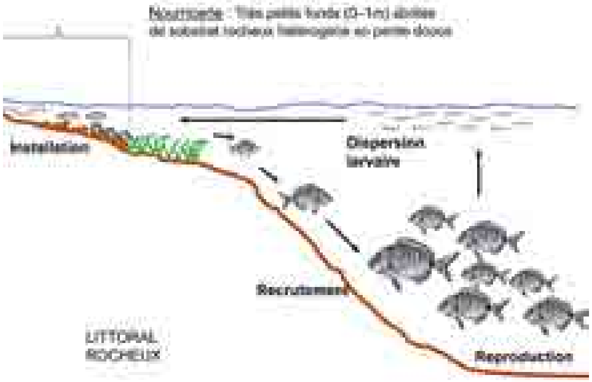
Introduction

The lifecycle of most coastal marine fish is complex and goes from pelagic larval dispersal phase to a relatively sedentary benthic adult phase. This is the case for the Sea bream and more precisely the *Diplodus* (Harmelin-Vivien et al., 1995) and which we will use to illustrate this fact sheet.

Breeding takes place in deeper waters than those usually frequented by adults. Once released, the eggs are fertilised in open water, then a larval period follows, the dispersal phase (Harmelin-Vivien *et al*., 1995). Then the larvae colonise specific habitats which are called nurseries in very shallow waters (Harmelin-Vivien et al., 1995). They then undergo a morphological transformation to the juvenile stage to enable them to adapt to their new benthic life (Jouvenel, 1997), this is the installation phase.

The recruitment phase corresponds to the integration of the juveniles in the adult populations (sexually mature) (Shapiro, 1987 in Pastor 2008).

Figure 48: Habitats which have a important role in the key stages of the lifecycle of certain fish (Teleostei) (amended drawing by Cheminée, 2012 done by Harmelin-Vivien in 1995)



Nurseries are essential for the conservation of the species and particularly the genus *Diplodus* where they are successively used by different species (Cheminée et al., 2011) including *Diplodus puntazzo*, *Diplodus vulgaris* and *Diplodus sargus* which all have a significant economic value (Jouvenel 1997; Vigliola, 1997).

It is therefore essential that the role of nurseries is considered in the management, planning and the coastal zone (Cheminée, 2012) to protect them from an artificial coastline and thus preserve their function.

Firstly, we suggest a methodology for identifying and mapping nurseries, then in a second step, an annual assessment of the intensity of settlement and juvenile recruitment.

Figure 49: Sharpsnout Seabream, *Diplodus puntazzo*

Figure 50: On the left, Sharpsnout Seabream, *Diplodus puntazzo*
On the right, two banded seabream, *Diplodus vulgaris*

Figure 51: Common Seabream, *Diplodus sargus*

Identifying and mapping nurseries

Three successive steps are necessary for identifying and mapping nurseries:

- pre-selection of potentially suitable settlement sites,
- characterisation and mapping of suitable habitats,
- settlement of juveniles in suitable habitats.

Pre-selection of potentially suitable sites

According to the work of Garcia-Rubies and Macpherson (1995) and Harmelin-Vivien et al. (1995), the Mediterranean's nursery habitats for the genus *Diplodus* are along the inner shore in very shallow, sheltered waters. These are gently sloping sites, heterogeneous substrate of pebbles, sand or gravel and small and medium-sized boulders. A macrophyte cover can be variable.

Figure 52: Nursery in heterogeneous substrate gravel, pebbles and small boulders colonised by macrophytes

In the study on nurseries done by Cheminée et al. (2011), he proposes to pre-select potentially suitable sites by analysing aerial photographs. Using as a reference the knowledge on the structure in *Diplodus spp.* nurseries studied in 1995 (sheltered, gently sloping site, heterogeneous substrate), the suitable sites are identified and the unsuitable ones removed.

For example, in the photos below (Figure 53, Frioul archipelago, Marseille), the red circles show pale coloured areas at the bottom of creek, these most certainly are shallow, sloping, relatively sheltered and thus suitable sites. But in contrast, the white crosses indicate dark and relatively open areas. These are less suitable because they are too steep and too exposed to prevailing winds.

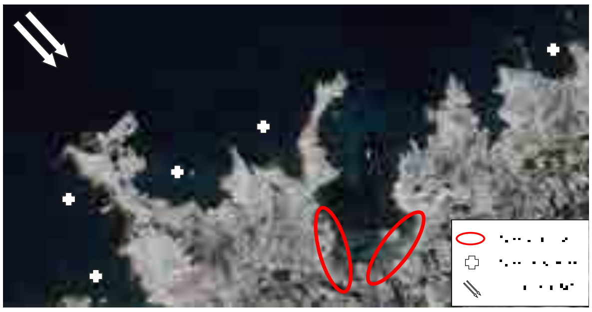


Figure 53: Pre-selection of potentially suitable sites to settle juveniles

Characterisation and mapping of suitable habitats

An in situ visit to pre-selected sites is necessary to characterise the habitats and then identify and map the ones suitable for the settlement of juveniles.

Habitat characterisation is performed in homogeneous sections of the coastline. Using a GIS, draw the coastline from an orthophoto of your study area. We recommend a working scale of 1:7000 for this exercise.

Attach the laminated orthophoto to one side of your waterproof slate (Figure 54) and on the other side a coastline drawing (Figure 55) printed on a waterproof sheet. Prepare the same number of cards as selected sites, using the same working scale.

Figure 54: Orthophoto

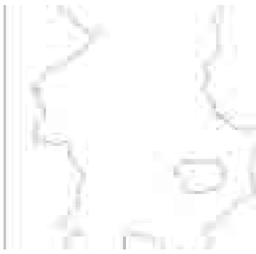


Figure 55: Coastline drawing

The orthophoto is more detailed and will help you to locate your position on the "Coastline" map. Place yourself 2 metres from the coast and swim parallel to the linear. Every measurement should be taken at this distance (the distance between two outstretched arms) Then divide the coastline into homogeneous sections and take the following characteristics for each section:

- Drop: presence or absence,
- Slope: 0-20 °, 20-40 °, 40-60 °, > 60 ° overhanging
- Substrate: sand, gravel, cobbles, boulders, rocks, herbal, bare (if no macrophytes)
- Exposure: calm, average, rough,
- Depth: measured using a marked, lead weighted cord.

The depth and slope are measured vertically below the diver. The depth can vary within a single section. Record your observations on a separate waterproof sheet.

The substrate is evaluated according to the following sizes (Cheminée, 2004); the ruler attached to the waterproof slate serves as a benchmark:

- Sand: < 1 cm,
- Gravel > 1 cm,
- Pebbles: > 6 cm
- Boulders: > 15 cm,
- Rock: rocky surface not in boulders.

Depending on the nature of the characteristics (drop, slope, substrate, exposure, depth) identified for each homogeneous section, potential nurseries are identified then mapped.

If any one of these characteristics is present, this coast cannot be validated:

- A drop of more than 2 metres deep,
- A homogeneous sand substrate on a large coastline (> 20 m)
- A homogeneous rock substrate,
- A slope greater than 40°,
- A depth greater than 2 metres,
- A rough exposure.

As an example, here is a habitat characterisation made on the Crine inlet in the Frioul archipelago. The inlet was divided into homogeneous sections (Figure 56) using the characteristics described in Table 7.

Figure 56: Homogeneous sections on the Crine inlet coastline

Section	Cliff	Slope	Substrate	Depth	Exposure	Suitable
1	yes	F	R+B+H	1,3 to 1,7	Average to rough	no
2	yes	D	S+GAN+GR	0,70	Average to rough	no
3	no	D to M	R+H	1	Average	no
4	no	D	S+GR+GA+B	0,30	Calm	yes
5	no	D	R+H	0,60	Calm	no
6	no	D	SA+GR+B	0,30	Calm	yes
7	yes	D	R	0,30	Calm	no
8	no	D	GA+B	0,20	Calm	yes
9	no	D	GAN+H	0,40	Rough	no
10	yes	M to A	R+GA	1,5 to 3	Rough	no

Table 7: Characterisation of homogeneous sections in the Crine inlet

This characterization has allowed to identify three suitable areas for the settlement of juveniles. These potential nurseries are shown in figure 57.

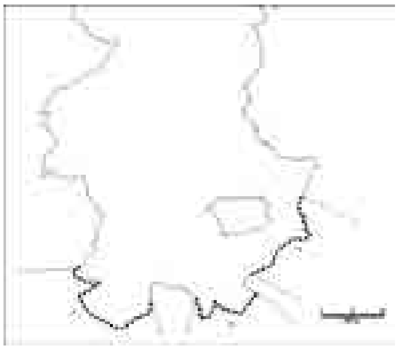


Figure57: Potential nurseries in the Crine inlet

Settling juveniles in suitable habitats

One last field trip during the settlement phase will be made in the selected suitable habitats. This will help to check for the presence or absence of juveniles. This validation phase is essential to qualify the habitats as nurseries. In fact, some habitats may have interesting potential as a host, but no juvenile settles there, due to unsuitable hydrodynamics for example.

D. sargus is the species we will use to validate the settlement of juveniles in selected micro-habitats. In fact, this species has several advantages over other species: (1) juveniles settle in accessible shallow marine water, (2) being confined in a depth of between 0 and 2 metres, (3) the arrival of juveniles occurs at the beginning of the summer season and (4) focuses on a relatively short period of time (Garcia-Rubies and Macpherson, 1995. Harmelin-Vivien et al., 1995), (5) juveniles settle in relatively large numbers, (6) remain in one place (Jouvenel, 1997).

Figure 58: *Diplodus sargus* juveniles (photo Adrien Cheminée)

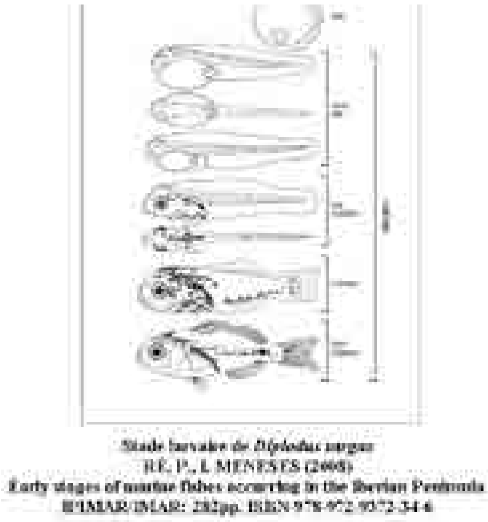


Figure 59: Larval stage of *Diplodus sargus*
RÉ, P., I. MENESES (2008). Early stages of marine fishes occurring in the Iberian Peninsula, IPIMAR/IMAR: 282pp. ISBN-978-972-9372-34-6

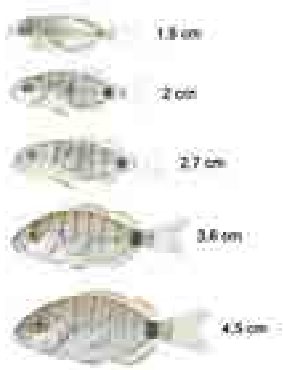


Figure 60: *Diplodus sargus* during their development (the sizes are not respected)
According to Lo Bianco *et al.*, 1933, Fauna and flora del golfo di Napoli

After checking the presence of juveniles, it is then possible to calculate the actual nursery's coastline area, based on the mapping carried out. The same scale as the preselected sites should be adopted for this reason. You can then evaluate the potential to host juveniles on the scale of your MPA or study area.

BE CAREFUL…

In a year when there is a low settling intensity, some nurseries will not host or just a few juveniles. Only a renewed monitoring over several years can set aside this or that coastline.

Also, one should note that during a settlement phase with a particularly strong intensity, a nursery can be saturated. In this case, some juveniles will be forced to move to less suitable peripheral areas. However, do not map the nurseries again, based on your new observations.

REMINDER

Moreover, if in the region the characteristics are not theoretically suited to settling juveniles; these can be installed in areas with rocky embankments. If no portion of the coastline is suitable, a second survey can be done within diked areas.

Annual evaluation of settlement intensity

Beck *et al.* (2001) assesses the value of a nursery by the recruitment success (the number of juveniles who joined the adult population). The nursery's value depends on biotic factors (eg, larvae nourishment, predation, competition, etc.), abiotic (eg. depth, physicochemical parameters etc.) and landscape (eg. spatial configuration, connectivity with adult population habitats etc.). These factors have an impact on the number of arrivals, growth and juvenile mortality and finally the number of juveniles who join the adult populations. Assessing the value of a nursery requires important fieldwork and analysis which is not possible with routine monitoring.

We propose, for each suitable site a simplified way to assess: (1) the annual settlement intensity of juveniles, (2) annual recruitment.

The settlement dates for juvenile *Diplodus sargus* is between mid-May and late June (Garcia-Rubies and Macpherson, 1995; Haremelin-Vivien, 1995; Jouvenel, 1997). In the nursery, juveniles settle in relatively grouped packs in just a few days (Jouvenel, 1997). The settlement peak is linked to the maximum number of settled juveniles (Jouvenel, 1997) and whose value represents the settlement intensity for a given year. Recruitment takes place between mid- August and early September (Macpherson, 1998).

Recruitment means the total number of individuals present in the nursery before they scatter to adult populations. This date corresponds to the end of the settlement period and takes into account some mortality. So this value is the number of juveniles potentially capable of reaching adult populations.

A quick tour of some of the nurseries at the end of May will allow you to confirm whether or not the clouds of 1 cm juveniles has arrived (Figure 60). Subsequently, two comprehensive juvenile counts will be made (in the north Western Mediterranean coast):

- One in mid-June after the settlement peak
- The other in early August before the departure to adult populations.

These dates are a theoretical base and come from work done on the northwestern coast of the Mediterranean. The juveniles' settlement dates may vary according to the years and regions in the Mediterranean basin. An adjustment is required based on the observation of 1cm individual clouds. You must take the first count ten days after the observation of the clouds and the second count about a month and a half later.

Figure 60: *Diplodus sargus* cloud (© Adrien Cheminée)

Field protocol

The time of day when nurseries should be prospected should be between 11am and 3pm, which corresponds to the middle of the day. Be careful during the two counting periods, every nursery should be visited on the same day if possible or on a very small number of days in the same time period. You should target a suitable weather window, lasting several consecutive days. Sea conditions and visibility must be optimal; the fish that you are counting are small and can be easily confused with suspended particles (Figure 61).

Figure 61: Suspended particles hindering the detection of juveniles

For the coastline exploration of each nursery, you should do a slow and steady swim so as not to double count the same individuals. Your observations will be for that distance of the coastline. Fish density will be calculated by linear meter. Just like when counting adult fish, an accurate evaluation of juvenile abundance will be done knowing that some approximation will appear over 20 individuals.

The size of the individuals is evaluated to the half centimetre, between 0 and 4 cm in length. Actual size silhouettes and the ruler set on the slate are used as a benchmark.

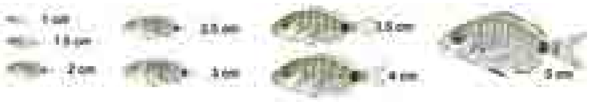


Figure 62: Full size silhouettes to evaluate the size of juveniles

Prepare a chart on a waterproof sheet to record your observations and also attach the map of sample nurseries. The columns correspond to the different size groups, the lines to nurseries. Be sure to give a unique number to each nursery.

Date :			Water temperature:			Weather				
Site 1	10	15	20	25	30	35	40	45	50	55
Nursery 1										
Nursery 2										
Nursery 3										
…										
Site 2	10	15	20	25	30	35	40	45	50	55
Nursery 4										
Nursery 5										
Nursery 6										
…										

Table 8: Example of a field table

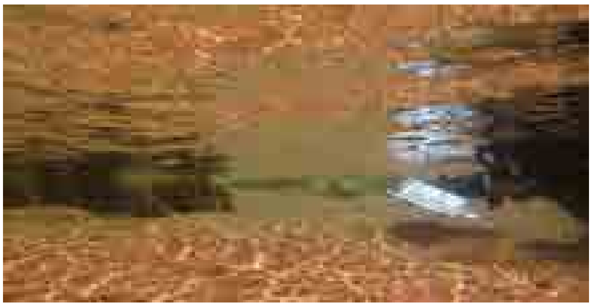


Figure 63: Diver performing a juvenile count (© Adrien Cheminée)

Use of sampling data

Entering and storing data

Data entry is performed on a spreadsheet as shown below (Figure 64). In the columns are the various parameters, the lines correspond to the nurseries. Record the number of fish observed per size group.

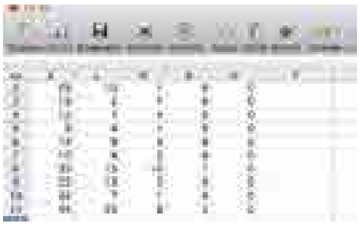


Figure 64: Example of data input file (fictitious data)

Capitalising on the data

To compare each station, you must do at least three replicas; these must be independent and identical in terms of characteristics. The stations can be creeks; the various pre-identified nurseries within each can be considered as replicas. You will calculate the juvenile density per linear meter for each transect (nursery). This line can be calculated using a GIS, using the same working scale as in the mapping. 1:7000.

Figure 65: Calculation of the total juvenile density per linear meter (fictitious data)

You can then do a graph using histograms.

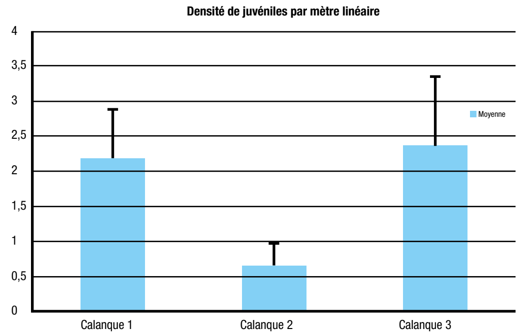


Figure 66: Density of juveniles per size group

You can also compare your stations by grouping the juveniles by size group; small, medium and large, for example.

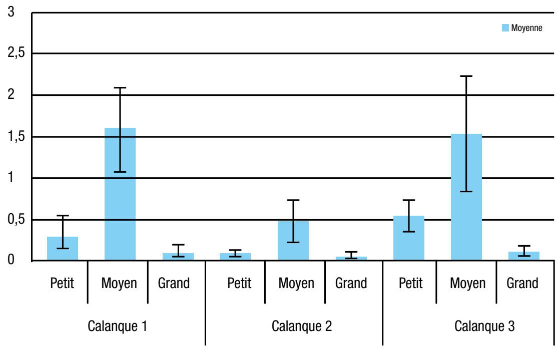


Figure 67: Density of juveniles per size group

Subject study example

Assess the impact of use (regular boat anchorage, very busy beaches etc.) on the settlement intensity and recruitment.

The same assessment can be done for pollution.

Moving towards a sharing and pooling of knowledge

The *Diplodus spp.* genus is widely represented across the Mediterranean. These species have a high commercial value for artisanal fishing. From an ecological point of view, the Sea Bream are predators of sea urchins, and so limit overgrazing in rocky areas. By protecting juveniles' critical habitats and supervising the fishing activities of adult populations, MPAs enable a return to a balanced demographic structure among fish populations and eggs and larvae are exported outside their borders (reserve effect). MPAs thus work to revitalise artisanal fishing businesses.

Pooling resources, data and knowledge across several MPAs would increase the effectiveness of their actions. Several scientific teams are working on recruitment and are highly motivated to support any initiative.

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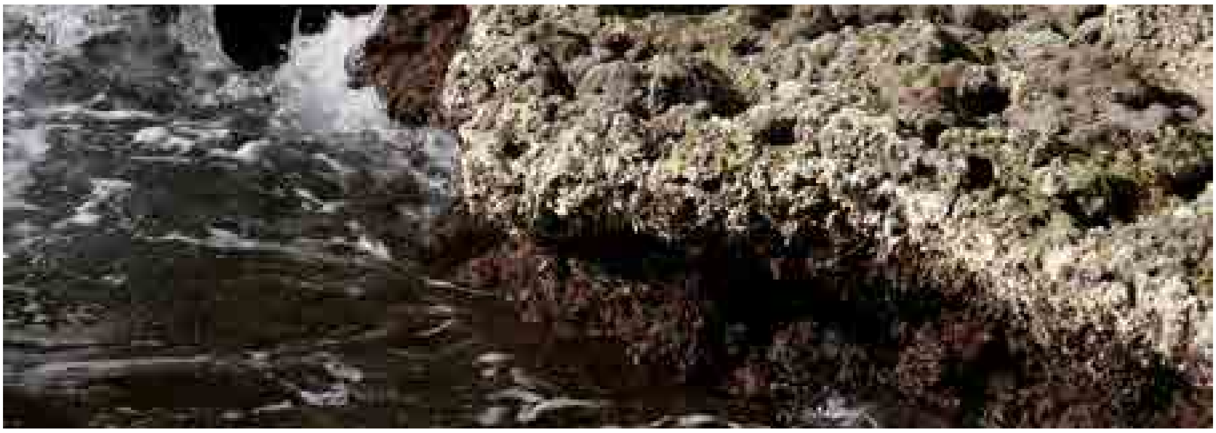
Mapping and evaluation of the vitality of bio-constructors:

Lithophyllum byssoides encrustations, *Vermetid* reefs, *Corallina elongata* and *Lithophyllum incrustans*



Introduction

The term bio-constructors refers to solid biological formations. Many marine organisms including some red algae attach themselves to limestone which has dissolved in seawater to build their skeletons (Valesi Pergent G. and C. Martini, 2011).

This is the case of *Lithophyllum byssoides*, a relatively common species in the northwestern Mediterranean (Figure 68) and on the northern part of the Atlantic (Verlaque, 2010). In most cases, the algae do not form beads but 20 to 30 cm diameter veneer fronds. These overhangs (or ledges) only take place on a hard rocky substrate along very battered coasts which are exposed to prevailing winds (Burn and V. Boudouresque CF, 2003).

Video tutorials

This methodological factsheet is also available as a video tutorial produced by MedPAN and available on youtube.

Start by watching the introduction video "Snorkel surveys of the marine environment" before moving on to the actual factsheet tutorial. Two other factsheets of this guide are also illustrated with video tutorials

https://youtu.be/x08q7Z7JkIk

https://youtu.be/F8NLNUVQBYg

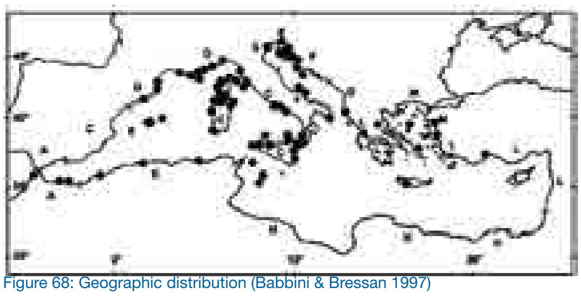


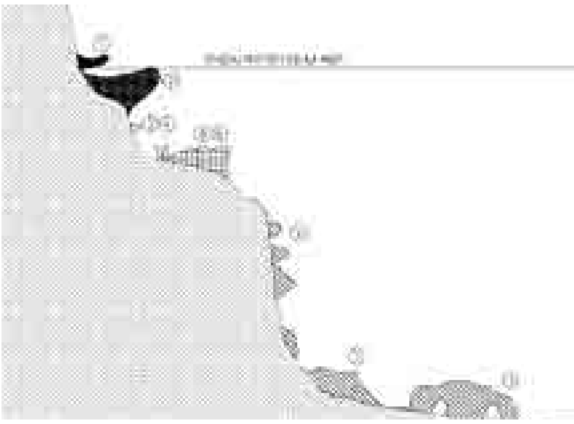
Figure 68: Geographic distribution (Babbini & Bressan 1997)

L. byssoides encrustations develop on a narrow strip of the lower intertidal zone, just above sea level. They are exposed to air pollution and marine pollution (Verlaque, 2010).

Moreover, *L. byssoides* have been seen to develop above dead encrustations in a few places in the Scandola Nature Reserve in Corsica (France) (Verlaque, 2010). The same phenomenon was found by Laborel *et al.* (1994b) in Marseille who believed that this phenomenon was consistent with the rising sea level recorded in the 20th century (Verlaque, 2010). As such, *L. byssoides* encrustations are indicators of the surface water's quality (short-term) and sea level (long term). *L. byssoides* encrustations are a Natura 2000 status habitat : elementary habitat 1170-12 lower interdidal zone rocks.

After presenting the morphology of *Lithophyllum byssoides* encrustations, we will see how to map them, assess their vitality and information you can get from monitoring them: organic or chemical pollution, rise in sea water level.

Finally, we will discuss other bio-constructors which are accessible by snorkelling: *vermetid* pavements, the *Corallina spp.* beads and *Lithophyllum* incrustans pavements.



1 : *Lithophyllum byssoides* rim,
2 : *Vermetid algal* rim,
3 and 4 : *Corallina / Lithophyllum incrustans* rims,
5 : *Cladocora* banks,

6 and 7 : *Algal " coralligenous "* bank.

Figure 69: Zoning of some forms of Mediterranean biogenic structures (Laborel, 1987)

Description of a *lithophyllum byssoides* encrustation

Located in small inlets or fissures exposed to the swell of the sea, the encrustations height and width can be increased locally (Picard, 1954; Blanc et Molinier 1955).

The internal organisation of an encrusted *L. byssoides* is made up of three different parts (Blanc and Molinier, 1955):

- A porous outer layer of living *L. byssoides*, a few centimeters thick, resting on unconsolidated dead fronds and located on the top and vertical surfaces of the encrusted layer
- Internally, a succession of hardened layers form a sedimentary deposit (hardened) filling the gaps between the slats,
- A lower eroded surface which is dead and abundantly colonised by subtidal organisms.

Figure 70: Schematic section of a *Lithophyllum bissoides* encrustation (Morhange and al, 1992).

L. byssoides form cushion-type clusters whose diameter varies in general between 8 and 15 cm (the most being 4 and 45 cm). Reaching a height of 1 to 2 cm these formations are composed of upright slats and are nestled within a set of dense braided tangles (Verlaque, 2010).

In a moist and shady environment, living colonies of *L. byssoides* are pink to dark purple (Verlaque, 2010). In contrast, dead colonies become greyish-white (Figure 71).

One can observe some slats without the same dark pink colour as one year old living colonies; this is an annual recruitment (photo 40).

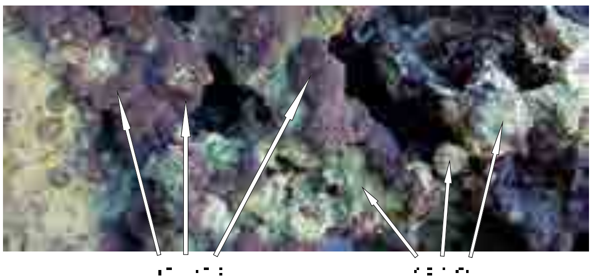


Figure 71: Presence of living and dead colonies on the surface of an encrusted *L. byssoides*

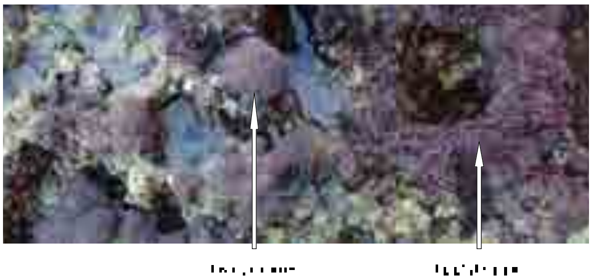


Figure 72: Living colonies and epiphytic algae cover

Figure 73: Annual recruitment slats

Mapping encrustations

Encrustations mapping is performed by travelling up and down the entire coastline with a small boat using the CARLIT method which was developed within the framework of the European Water Framework Directive (Ballesteros *et al.*, 2007).

Using a map of the study area (marine chart or aerial photo or orthophoto), the presence of encrustations is noted down during the observations. Only the presence of encrustations is noted, leave the fronds of *L. byssoides* with no beads aside. The map's scale should be large enough to allow the inclusion of smaller encrustations (<1 m long). A scale of 1:5000 is recommended (Ballesteros *et al.*, 2007). Only encrustations exceeding a 50cm line will be mapped.

The length and width of each encrustation is measured. Its position linked to the biological zero (medial and infralittoral limit) is also noted down. As well as the sub-tidal algae limits (often these will be *coralline algae*).

Depending on the coast's configuration and the size of your boat, it will then be easier to take measurements by snorkelling.

Figure 74: Distribution of L. Byssoides encrustrations in the Frioul archipelago

Vitality evaluation

The vitality of an encrusted *L. byssoides* is measured on its upper side and possibly its front side when the encrustation is found in a high coastal position (strong hydrodynamics sector) (Verlaque, 2010).

The rule is to evaluate with random or continuous sampling, the percentage of coverage of different categories such as: living colonies (V), the annual recruitment (R), dead colonies (M), the sections colonised by *epiphytes algae* (A) and empty sections (biological holes or architectural) (T).

An autumn sampling

Assessing the vitality of an encrusted *L. byssoides* must be done in specific climatic conditions. The appearance of the *L. byssoides* encrustations evolves during the year depending on the moisture provided by the waves, temperature and irradiance (Verlaque, 2010). In winter and frequent rough seas, field campaigns are difficult to carry out (remember encrustations are located on very battered, rocky coastlines!). In contrast, the summer often has ideal sea conditions but the scorching sun and high temperatures cause *L. byssoides* to dry out and bleach, which makes it impossible to differentiate the living portions from the dead ones. Verlaque (2010) showed in a spring study of the *L. byssoides* vitality that the differentiation between living portions of *L. byssoides* and dead ones was hampered by the living *L. byssoides* faded colour and the soft bloom of medio-littoral algae. Autumn is the most suitable period for evaluating the *L. byssoides* vitality, the month of October being the best. One must also choose suitable weather conditions with high atmospheric pressure if possible in order to work in low level waters.

Assessing the vitality from photographs

Place a metric benchmark on the encrustation to determine the scale of the image. It is better to use a rather dark tape measurer (or other) to avoid overexposure.

Then take a bird's-eye view of the surface of the encrustation, taking care that the tape measure is in the lower part of the photo.

Back at your computer, improve the colour contrast if necessary and draw a grid of 20 cm x 20 cm for example with a 2 cm mesh size (Figure 75). Use the scale given by the tape measure to help you.

Another method is to place a known sized quadrat on the encrustation and then zoom and take a photograph of the area covered by the quadrat. The same analysis method will be used.

Figure 76: 20x20 cm Quadrat with a 2 cm mesh size

The assessment of the encrustation's vitality within each 2 cm x 2 cm square of the quadrat will be transcribed using the following categories:

V	Living colonies	31 %
R	Annual recruitment	7 %
M	Dead Colonies	11 %
A	Epiphytic algal cover	28 %
T	Hole	23 %

Table 9: Percentage of different coverage categories

In each square, the category which covers the majority of the surface (50% and over) will be noted down.

According to Figure 76, the following representation is obtained:

	1	2	3	4	5	6	7	8	9	10
A	A	A	A	T	T	T	A	A	A	A
B	A	T	V	V	T	T	A	A	A	A
C	M	M	V	V	T	T	T	A	A	A
D	T	V	M	V	V	T	T	A	A	A
E	T	T	A	A	V	R	T	A	A	A
F	T	V	V	V	V	R	A	A	A	A
G	V	V	V	V	T	T	T	T	R	A
H	M	V	V	V	V	M	V	V	R	M
I	V	V	V	M	M	M	T	T	R	V
J	V	V	V	V	T	M	R	R	M	V

Table 10 : Identification and distribution of categories in a 20 cm x 20 cm grid

The results of the coverage rate will be given in percentages of the total sample area and compared to the *L. bissoides* encrustation's total surface area.

Rather than evaluating the coverage area within each square, you can just take into consideration the intersecting lines. Then identifying the coverage at each given point on these intersections.

In the case of a narrow encrustation, it will be possible to follow the same methodology with just a tape measurer. Using your photographs, you can then determine the different categories (V, R, M, A, T) every cm along a 1 meter transect for example.

There are two other methods to analyse a photo. The so-called "surfacing method", it is very accurate and digitalises the photo. Software such as CPCE (Kohler and Gill, 2006) calculates the surface area occupied by a particular category. Despite this method being the most reliable, it is long to implement and requires a very good image quality. The other is called "Random Point Count Methodology: RPCM" and is an analysis by points placed randomly on the photo. This is a rapid method to implement and statistically valid and has a definite advantage, but requires a relatively large number of replicates. Moreover, there is a risk of making a poor estimate of the rarest category (either underestimated or overestimated).

Methods	Advantages	Disadvantages
Digitalisation	• Very reliable estimate, close to reality	• Takes a long time to achieve • Needs a very good picture quality • In the case of repeated monitoring, requires well located permanent quadrats as the reliability and interpretation depends on them
RPCM	• Rapid implementation • Objective method • Statistically valid	• Incorrect estimation of rare species (i.e. underestimated or overestimated) • Number of replicates required depends on biodiversity

Table 11: Advantages and disadvantages of photographic methods

Evaluation *in situ*

The methodology will be exactly the same as above except that the evaluation will be conducted in the field using a quadrat grid (Figure 77) and/or a measuring tape. You simply place the quadrat or measuring tape (randomly or according to the permanent buoy markings) on the encrustation's surface and then determine the V, R, M, A, T categories. You will have previously prepared a numbered grid on your waterproof slate where you can record your observations.

Figure 77: Example of a PVC quadratic grid

The configuration of some encrustations (narrow and/or steep sided) will prevent you from taking good quality photographs. The sampling will be carried out by using both the photographic method and the evaluation in situ method.

Whether permanent or random sampling, you will need at least 20 replicates per encrustation.

As part of an ongoing sampling programme, select areas featuring easily identifiable landforms (spikes, holes etc.) rather than putting buoy markings which will make the site artificial.

Figure 78: Permanent linear transects identified by a characteristic rocky point

Lessons learnt from evaluating the vitality of *L. Byssoides* encrustations

L. byssoides encrustations as indicators of water quality

Located on the lower part of the intertidal zone, the encrustations may be subject to various types of pollution from the land (runoff) or from the sea.

Organic Pollution

In the case of organic pollution, eutrophication can promote species such as green algae or mussels. Its presence or absence will be recorded systematically as well as the species or its kind (if it is impossible to determine). The percentage of organism coverage will be evaluated according to the method described in paragraph 3.

Chemical Pollution

The important presence of leisure, cargo or other vessels with wastewater discharges may affect the *L. byssoides* encrustations' vitality. It is not possible to assess a decline in vitality of an encrustation due to chemical pollution without analysing the water. If there is a doubt in the seawater samples, an analysis will be needed to confirm whether or not the assumptions are correct.

Trampling on *L. byssoides* encrustations

In some cases, the encrustations can be used by users such as kayakers to land on the coast. A large number of visitors and important trampling can damage these remarkable formations.

Access to these parts of the coast must be supervised by the manager to prevent trampling on these encrustations.

In permanent transects, it could be interesting to conduct vitality assessments where encrustations are known to be used for visitor's landings. Users can also be fishermen on foot.

As described in paragraph 3, a vitality assessment will be done on the smooth white parts (freshly pulled). A highly trampled encrustation will have crested ridges. In some cases, an annual visit to the most problematic areas will be necessary.

The vitality of *L. byssoides* encrustations as indicators of the rising sea level

The most significant effects on the rise in sea level will be observed in the encrustations closest to the sea level.

This is surf height which determines the height of the biological 0 (given by the Coralline limit - *L. byssoides*). This varies depending on the seabed's morphology (shoals) and the coastline (very narrow inlets, cracks etc.).

In the case of a small inlet, the outer part of the encrustation will be lower and therefore more exposed than the one located at the end of the inlet.

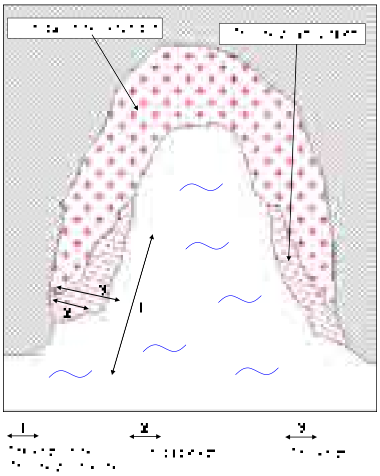


Figure 79: Evaluation of *Corallina spp*. coverage

The development of *Corallina spp.* on top of an encrustation is a sign of a rise in sea level. These species usually grow on the lower part of an encrustation, an area more exposed to immersion by the surf. The *Corallina spp.* coverage is assessed by noting the steps shown in the diagram above. The steps (2) and (3) are recorded at least three times along the length (1).

Returning on site every 5 years will be sufficient to note any changes.

Other bio-constuctors accessible to snorkel surveys

Apart from *L. Byssoides* encrustations, there are several other bio-constructors in the Mediterranean. Indeed, three other surface and sub-surface formations can be distinguished along the coast (Laborel, 1987):

- vermetid pavements
- *Corallina spp.* cornices
- *Lithophyllum incrustans* pavements

Even if the assessment of these formations' vitality is complex, mapping them with their main characteristics is quite possible.

We draw your attention to the fact that identifying specific formations can be complex. Also we recommend a consultation with experts before initiating any kind of monitoring.

Vermetid Pavements

This formation is partly made up of a combination of two species : a gastropod from the Vermetides family, *Dendropoma* (Novastoa) *petraeum* (Monterosato), often referred to as the *Vermetus cristatus* in literature and *corallinaceae calcareous algae*, *Neogoniolithon brassica-florida* (Harvey) Setchell & LRMason (= *Neogoniolithon notarisi* (Dufour) G.Hamel & M.Lemoine) (Laborel, 1987).

The ratio between the two species is very variable depending on environmental conditions.

The morphology of the vermetid constructors is variable, three types of formations can be distinguished (Laborel, 1987):

- pavement or platform : due to soft rock erosion
- atoll: from a complex combination of constructive and erosive forces
- cornices: along vertical cliffs, these formations are similar to *Lithophyllum byssoides* encrustations

The vermetid constructors linked to tropical strands are confined to warm waters and are usually found in the eastern basin of the Mediterranean.

Just like *Lithophyllum byssoides* encrustations, vermetid pavements are sensitive to marine pollution and mechanical degradation by trampling.

Corallina spp. cornices

Corallina cornices are built from the dense development of coralline by retaining in their limestone fronds significant amounts of detrital components. These elements are cemented by encrusting algae *Phymatolithon lenormandii* (Areschoug) W.H.Adey (= *Lithothamnion lenormandi*i (Areschoug) Foslie) (Molinier, 1955).

These formations, vassals to vertical rocks, can meet under the *L. byssoides* encrustations. They are not just located near the surface, but can meet a few meters further down.

Distribution

Located near the surface, *Corallina spp.* cornices are subject to surface pollution.

Lithophyllum incrustans pavements

Found in the upper part of the infra-littoral down to a few meters in depth, this encrusting algae can form small encrustations in a very battered zone.

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Inventory and monitoring of the *Pinna nobilis*

Introduction

The pen shell, *Pinna nobilis*, is endemic to the Mediterranean Sea and is one of the largest existing shells worldwide. Measuring up to 1 meter it is a bivalve mollusc that is part of the Mytiloïdes order and from the Pinnacées super family (Vicente N., 1984).

The healthy population of pen shells often lives fixed to the *Posidonia* meadows mat but it can also be found in a variety of environments such as *Cymodocea* seagrass, dead mat or maerl beds and sometimes at the base of boulders (García-March JR and N. Vicente, 2006).

***Pinna nobilis* normally has its shell tip pressed into the sediment, depending on the hydrodynamics (Vicente N., 1986). It fixes itself with byssus threads which are glued either to *Posidonia* roots and rhizomes or sand, pebbles or other depending on the nature of the substrate (García-March JR and N. Vicente, 2006).**

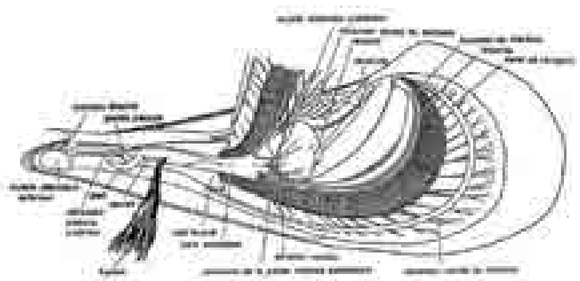


Figure 80: Overview of the *Pinna nobilis* body after folding back the left side of the mantle. The gill and the left side of the mantle are partly cut (after Czihak and Dierl, 1961).

The pen shell is a great base for many epibiont organisms (photo 44) and can accommodate between its valves commensal species such as the shrimp *Pontonnia pinnophylax* or crab *Pinnotheres Pinnotheres* (Vicente N. and JC Moreteau, 1989). Individuals can be seen in the first meters of shallow coastal waters or to depths of up to 40 meters and even 60 meters (Templado *et al.*, 2004 in García-March JR and N. Vicente, 2006).

The number of *Pinna nobilis* has declined considerably in recent decades, especially on the northern Mediterranean coast, due to anthropogenic impacts such as coastal development, the destruction of *Posidonia* meadows, trawling, boats anchoring, collection for a souvenir or fishing for eating its flesh (Vicente N., et Moreteau J.C., 1991; García-March JR and N. Vicente, 2006).

An individual's longevity and sedentary life means that the *Pinna nobilis* is a good indicator of the quality of the Mediterranean's coastal environment. Sensitive to marine pollution and mechanical damage, the reappearance and presence of individuals in shallow waters is a sign of a healthy coastline (Vicente N. *et al.*, 2002). The pen shell has different levels of protection status: Appendix 2 of the Barcelona Convention, Appendix 4 of the Fauna-Flora Directive, law of 26 November 1992 stipulating the list of the protected fauna on the French territory.

Since *Pinna nobilis* individuals are found in great depths, snorkelling is not a good method to observe individuals beyond a certain depth. Detection in a *Posidonia* meadow would also be delicate with snorkelling.

However, it is important to note and systematically map the individuals observed on the ground. Without doing comprehensive surveys, these observations will enrich the natural heritage knowledge of your site.

In the case of detecting a suitable site for the recruitment and development of this species, we will see how to make a quantitative estimate of the population on the one hand and time tracking on the other.

Figure 81: An individual colonised by various organisms

Writing observations on the pen shell

During your field trip, you will sometimes observe pen shells without actually looking for this species. However, these observations must be carefully noted down. The parameters to enter on your waterproof slate are:

- Date
- The inlet or area's name or the nearest rocky point
- Substrate
- Depth
- Details of the features in the surrounding landscape,
- Approximate distance from the coast,
- Take a measure of the overall sediment height using the ruler set on your waterproof slate.

If you have a camera during the observation:

- take photos of the pen shell,
- position yourself above the pen shell and take photos of the coast.

If you have a GPS during the observation:

- take GPS coordinates of the point by placing yourself above the pen shell.

The accumulation of these observations over time can help identify suitable development areas for this species.

Quantitative evaluation of the pen shell on the scale of a bay

Selecting the site

The distribution of individuals is variable and depends on environmental parameters. Thus in strong hydrodynamic conditions, individuals will tend to be located sheltering in a Posidonia meadow rather than outside it.

There will be a higher density of *Pinna nobilis* in sheltered areas rather than exposed ones (García-March JR and N. Vicente, 2006). Your comments and any previous data and all reliable reports (diving or other) will make up a useful knowledge base to identify sites where the species is well represented.

Surveys

It is possible to estimate the *Pinna nobilis* population size on the scale of an inlet or a bay by making surveys from the surface. These surveys will be limited by the depth and clarity of the water. Surveys may reasonably extend to depths of up to 8 to 10 meters, where there is good visibility and open environments.

Three or more divers will go back and forth surveying the study area, following markings taken from the surface. Divers should be in a line and swim at equal distance from each other holding a tight rope between them (Figure 82). The distance between divers will be between 2 and 3 m.

Figure 82: Exploration of a potential *Pinna nobilis* site by three divers from the surface

Whenever an individual pen shell is observed on the bottom, divers stop and mark its location using a weighted float (pictures 46 and 47). pen shell is thus marked during the observations. This avoids creating duplicates during an exploration phase.

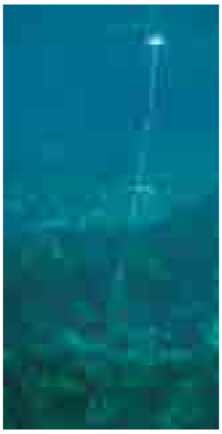


Figure 83: Temporary markings of *Pinna nobilis* using ballasted floats
On the left a view of the plumbline positioned near the pen shell, on the right the float on the surface

Once the survey has been completed, the number of individuals is counted, giving an estimate of the size of the population.

The number of *Pinna nobilis* may be underestimated according to the nature of the sea bottom, especially in the case of dense *Posidonia* seagrass coverage. To avoid excessive underestimation of small size groups which are difficult to observe, only individuals larger than 5 cm should be taken into consideration.

Capitalising on data

It is possible to draw a map of identified individuals using the main habitat map of the study area (Figure 84). This map is drawn on a waterproof slate with tracing paper. If this method lacks precision for monitoring individuals over time, it can quickly assess the distribution of pen shells within the study area and identify suitable places to set up permanent transects in order to monitor more closely individuals. Depending on the accuracy you want to achieve, the GPS coordinates of each individual are taken by placing the GPS above the pen shells.

Figure 85: Noting pen shells' individual positions observed in the field on a background map

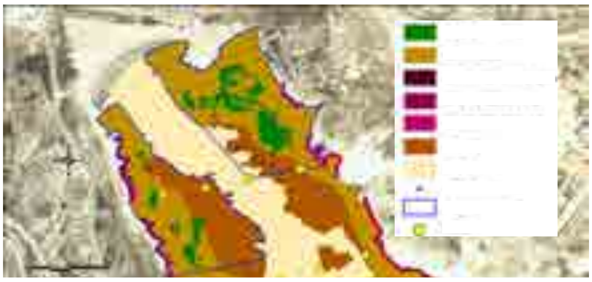


Figure 86: Example of pen shell mapping, the Posidonia meadow and Cystoseira belt done on the Frioul archipelago

Monitoring *Pinna nobilis* populations along permanent transects

Selecting the site

The study site will be chosen based on the recruitment and development potential for the species. Detection of P*inna nobilis* within a *Posidonia* meadow is tricky especially for small individuals in dense seagrass. The open areas such as dead mat seabeds which are more suitable for the recruitment of this species are the best sites for snorkel monitoring.

The quantitative assessment presented in the paragraph above will help you to identify suitable sites to set up permanent transects for time tracking pen shells.

Monitoring a population will assess the impact management actions have on the pen shell population such as banning leisure anchorage or creating an underwater trail.

Making transects

The rule is to place inventory corridors on the bottom of known surface area. Their length depends on the sites and sampling choice. For the width, we recommend not to exceed 2 meters per observer. The identification of pen shells in these sampling areas must be comprehensive.

The beginning and end of the transect will be marked with a surveyor tag (tag, mooring and mooring shoot) or a steel rod set in the substrate (Figure 87). You can add a float between two waters, to easily find your fixed points. Take the GPS coordinates of each of the fixed points, and any information you deem useful to find them. Photos of the floats can also be taken, especially if it is a flat coast with geographic landmarks in the background, which will help you to get more precise alignment points.

Figure 87: Diver attaching a tag to the substrate using a tether. The hammer strikes the mooring shoot, placed above the tether. Shoot-tether is removed when the tether is adequately fixed.

A measuring tape is stretched between the two ends of the transect. Surveys are carried out in parallel on either side of the transect by moving marked rods (Figure 88). The left and right lanes can be surveyed simultaneously by two divers.

Figure 88: Pen shell inventory along a permanent transect

Surveys can be conducted from the surface, however short, slow dives above the sea bed will enhance the observation of the pen shells (Figure 89). The diver can obviously take pauses by putting the rod on the bottom to show the area already surveyed. In the next dive, he can resume his survey exactly where he left off.

Figure 89: Two divers surveying a pen shell inventory corridor

For each individual seen along the corridor, the coordinates given by the measuring tape and marked rod are noted down. The horizontal axis (X) is given by the rod and the vertical axis (Y) by the tape measure. The left side is noted with a negative x-axis while the right side is noted with a positive x-axis (Figure 90).

Figure 90: Reading the position of an individual along a permanent transect with a marked rod.

This methodology enables to find the pen shells' density: the number of pen shells identified over a surface of 100 m². The calculation of the density allows to compare sites in the same environmental conditions, but managed differently (anchorage exclusion zone for example). Returning on site after an annual cycle will help to update the mapping and monitor the population over time (number of individuals and individual growth.) Even if this method can accurately locate individuals for monitoring over time, it is advisable to mark individuals using a small slate with a unique code.

Marking individuals

The mark-recapture technique enables monitoring individuals over time. This marking is particularly useful if there are several individuals. However, the marking must be discreet so as not to make the presence of the pen shell too obvious. The mortality rate is quite high in juvenile shells (Vicente N., et Moreteau J.C., 1991), only the ones over 10 cm should be marked.

The markings must be durable as well as harmless. The rule is to use a small plastic slate with the individual's unique ID number. The slate is loosely attached by a cord around the pen shell in the sediment (García-March JR and N. Vicente, 2006). To avoid erasing the ID, a coded marking can be used (Figure 91)

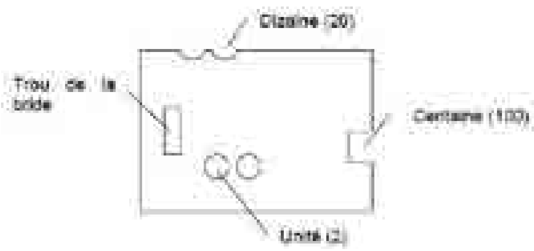


Figure 91: Example of coded plastic slate with number 122 (García-March J.R. et Vicente N., 2006)

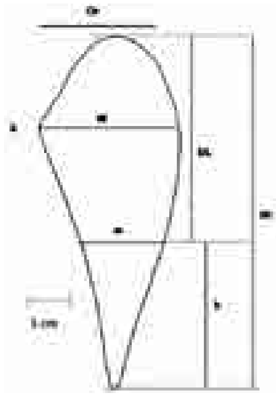
Measuring individuals

Even if you do not aim to study the growth of pen shells, we recommend measuring individuals using the method described below. It does not take a lot of time and this data will be useful for the day when you want to do closer monitoring.

Below are the items that will be needed to achieve a precise monitoring of an individual's size.

The total height of individuals (sediment height + height out of sediment) cannot be measured directly, without having to tear the pen shell from its substrate, which is not recommended as it may interfere strongly in the growth and survival of individuals thereafter. To overcome this constraint, three measurements are taken to estimate the total height of a pen shell (García -March JR and N. Vicente, 2006), these are:

- The maximum width (W)
- Minimum width (w) (measured at the sediment),
- Outside the sediment height (UL).



b: shape ;
h: length of the embedded part;
Or: direction of the opening;
UL: unburied length;
W: maximum width;
w: minimum width.

Figure 92: Measurements to estimate the maximum shell height (Ht) of *Pinna nobilis* (according to García-March J.R. and Vicente N., 2006).

According to studies done on the population of pen shells in MPAs, three formulas enabling to calculate the total height (Ht) of a shell were determined (Garcia-March J.R. et Vicente N., 2006):

- Gaulejac & Vicente Equation (1990) : $Ht = 2{,}186\ W + 1{,}6508$,
- Garcia-March & Ferrer Equation (1995) : $h = 1{,}79\ w + 0{,}5$ avec ($Ht = h + UL$),
- Garcia-March Equation (2006) : $Ht = 1{,}29\ W^{1{,}24}$

To validate the above formulas, these must be tested on whole dead shells collected in the field.

Hydrodynamics strongly influences the growth of pen shells. Also, it is imperative to take this into account when studying the growth of populations (García-March JR and N. Vicente, 2006).

For more information, refer to the *Pinna nobilis* in Marine Protected Areas monitoring population protocol study published by MedPAN and MEPA (2006).

To take measurements of shells on the ground, we recommend the use of a large compass, with two points at each end (Figure 93). The use of a compass will help you to easily obtain the shell's correct size by using both points. The measurement reading will be made by plotting the distance of the two arms on the waterproof slate's ruler.

Figure 93: Diver with a compass ready to measure a pen shell.

Figure 94: Diver measuring the maximum width of a pen shell with a compass

Figure 95: Measuring the distance given by the compass

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Mapping the upper limit of the *Posidonia meadow*

Introduction

Posidonia (*Posidonia oceanica*), recognised as a priority habitat by the European Community and protected by law in many countries, is one of the Mediterranean seabed's key species. *Posidonia* is a photosynthetic plant that grows in the first few meters (the upper limit) and between 15 and 40 meters in depth (the lower limit) depending on the water clarity.

Posidonia is a marine phanerogam consisting of creeping or upright stems generally buried in the sediment (rhizomes) and ending in groups of leaves which are called bundles (Boudouresque CF and A. Meinesz, 1982). The leaves high density and the network of rhizomes form a sediment trap. The web of rhizomes (little putrescible after death) clogged with sediment form a very solid set, called the mat (Molinier and Picard, 1952; Boudouresque CF and A. Meinesz, 1982). The rhizome grows very slowly, around a few centimetres per year. The progress of a meadow front, thanks to the growth of creeping rhizomes (plagiotropic) is around 3 to 4 cm/year on average (Caye, 1980).

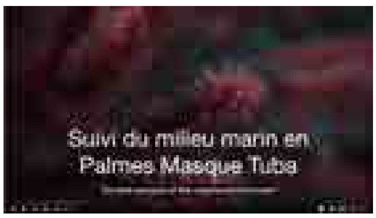
Endemic to the Mediterranean Sea, seagrass beds play an important role on different levels:

- Important oxygen production
- Stabilising soft sea beds,
- Protecting shorelines from erosion,
- Shelter and nursery role for many marine species,
- CO2 capture
- Fixing sediments (water clarity).

Video tutorials

This methodological factsheet is also available as a video tutorial produced by MedPAN and available on youtube.

Start by watching the introduction video "Snorkel surveys of the marine environment" before moving on to the actual factsheet tutorial. Two other factsheets of this guide are also illustrated with video tutorials



https://youtu.be/x08q7Z7Jklk

https://youtu.be/yjrviAVRBQY

Posidonia meadows play a major economic role (Boudouresque *et al.*, 2006) as a guarantor of the marine resources exploited by small fishery businesses, but also the coastline's quality and thus helping with tourism.

Seagrasses are subjected to many anthropogenic pressures and have decreased. The main pressures (Boudouresque *et al*., 2006) are:

- maritime constructions
- replenishing the beaches,
- dredged material - solid waste (macro-waste)
- water activities marking buoys,
- anchorage,
- aquaculture (fish and mussel farms)
- underwater pipelines,
- waste waters from treatment plants,

Due to the very slow growth of seagrass beds, monitoring techniques must be very precise to be able to notice a change. Scuba diving is more suitable to do this as snorkelling does not achieve this precision, except in barrier reefs.

The study of a *Posidonia* meadow's vitality is complex and requires several parameters being monitored. For example, the study of the meadow's density requires repeated underwater counts which should be done by scuba diving even in shallow seagrass (except in the case of a barrier or surface reef) to avoid observation bias.

However, snorkelling as a tool can complement several others in monitoring a meadow. Mapping the upper limit is easily accessible thanks to the excellent quality of aerial images. However, some areas may be poorly covered or have a bad definition. Sometimes, another substrate can be confused with sub-tidal rock, but snorkelling along this area can clarify and validate such a situation.

Noting the upper limit in the field

monitoring the upper limit will be done using a GPS. This type of tool is more or less accurate; the choice will be made according to monitoring needs and budget! This technique allows to survey large areas in a short time. As always, weather conditions and visibility will determine the quality of the survey. Place the GPS in "trace" mode and set it to gain points in short time intervals, every second, if the GPS memory allows. The GPS is then placed in a waterproof container (flexible or rigid) and deposited on the raft.

Figure 96: Setting the GPS

The diver then swims pushing the raft and remains as much as possible above the meadow, following the ouline and convolutions of the meadow.

Figure 97: The diver swims following the meadow's contours

If, as in the example above, there isn't a lot of depth you can also do this type of monitoring on much deeper sea depths (10 - 15 meters, or more depending on local visibility conditions). Obviously, the greater the depth, the less accurate it will be.

Representation of the meadow's upper limit on google earth

The boundaries of the meadow that you have saved on your GPS can be viewed on the Google Earth's free programme. Each GPS tracks records in a data format which can be recognised directly by Google Earth or not. If the format is directly recognised, simply load the data file through the tab "open", by specifying the file type (GPS format). If the format is not supported by Google Earth, the main current GPS manufacturers have a dedicated software available (Mapsource for Garmin GPS for example) for data visualisation. This software also converts the basic recording format to an export format for

Google Earth (kml or kmz type).

In Figures 98, 99 and 100, three representations of the same meadow trace are presented. They were taken with two different kinds of GPS (Garmin (precision 5-10 °) and Thales). For the Thales GPS, two plots were taken, the first without processing the data (accuracy of 1 to 5 m) and the second with a post-processing of the data (sub-meter accuracy). The post-processing was done using the GPS software. It corrects the geographical co-ordinates by taking into account the precise position of the satellites at the time of recording (satellite position). The satellites' position is downloaded directly from the GPS software.

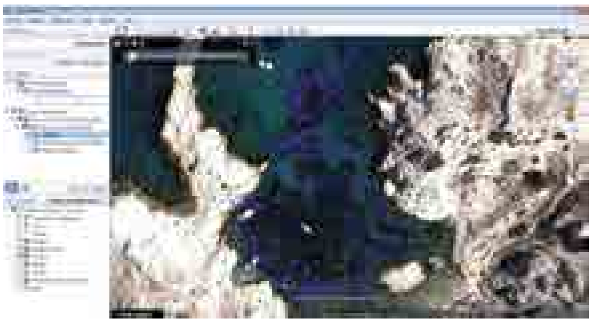


Figure 98: Representation of the meadow's boundaries with a Garmin GPS

Figure 99: Representation of the the meadow's boundaries with a Thales GPS

Figure 100: Representation of the meadow's boundaries with a Thales GPS after post-processing data

This method enables to map the boundaries of the meadow which were poorly covered by aerial photographs. For a closer monitoring of the Posidonia meadow (vitality etc.), we would refer you to the many books written on the study and conservation of this species, such as:

- Boudouresque *et al.*, 2006 - Préservation et conservation des herbiers à *Posidonia oceanica*, Accord Ramoge.
- Noël *et al.*, 2012 - Cahier technique du gestionnaire - Analyse comparée des méthodes de surveillance des herbiers de posidonie, Cartocean, Virtual Dive.

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Monitoring the populations of the edible sea urchin, *Paracentrotus lividus*, on rocky sea bottoms

Introduction

The edible sea urchin, *Paracentrotus lividus*, is a common species in the Mediterranean's shallow rocky seabeds. Belonging to the echinoderms phylum and echinoids family, the edible sea urchin is a marine organism which has a circular test completely covered with spines. The adult's test is between 4 cm and 7 cm. An individual's colour can vary from olive green to brown through various shades of purple, but never black thereby distinguishing itelf from its close relative, *Arbacia lixula*. Usually found in shallow waters, the edible sea urchin lives on heterogeneous seabeds like rocky bottoms or the *Posidonia* meadow matte and sometimes on sandy detrital seabeds. Its presence is subject to the presence of macrophytes as they are its main food source.

A large part of the Mediterranean particularly appreciates the taste of this species (The Direac'h, 1987). In some areas, despite fishing supervision, the individual density of this species is in decline; this is the case in the Marseille region (Bachet *et al.*, 2011).

In other regions by contrast, there is a high density which causes overgrazed landscapes. These abnormally high densities may be the result of several phenomena. If weather conditions are favourable for an exceptional spawning, a lack of plankton larval predators even at a benthic juvenile stage, often explains the proliferation of sea urchins (Breen and Mann, 1976; Tegner and Dayton, 1981). The two main Mediterranean predators are the seabream *Diplodus spp*. and the rainbow wrasse *Coris julis* (Hereu *et al.*, 2005, Goni *et al*., 2000).

On the Mediterranean's upper infra-littoral, *Paracentrotus lividus* plays a key role as one of the main herbivores in the Phytobenthos dynamics. Thus a small, balanced population promotes increased heterogeneity and specific diversity in the vegetation. In contrast, when densities increase, the tree algae and associated fauna are gradually replaced by undiversified encrusting algal communities. A final stage where the rocks are stripped bare can occur when P*. lividus* predation becomes very intense with an overgrazing facie. (Verlaque, 1987).

So time tracking this species' density can be very interesting:

- In terms of resource management where the species is exploited,
- In terms of ecological watch to assess any possible imbalances (abundance or decline in the number of individuals.

Sampling stations

In this chapter, we have used th existing standardised-methods that have routinely been used for the 20 years in the Blue Coast Marine Park (Bachet *et al.*, 2011). So, due to the aggregative nature of the species, we recommend random sampling which requires an important number of replicas for the results to be statistically valid. Moreover, for monitoring over time, it is wiser to do counts along permanent transects thus ensuring comparable data.

Selecting the stations

When doing snorkel sampling, it is best to choose shallow areas (< 3 meters) as these are predominantly rocky environments. When the Posidonia meadow coverage is good, it is difficult to find urchins when snorkelling. Thus, the deeper transects (> 3 m) and where the Posidonia meadow coverage is over 10% should be reserved for scuba diving. Therefore, snorkelling complements scuba diving and allows you to extend the sampling to rocky shallow waters where there is important fishing pressure.

The case of monitoring fished populations,

When selecting stations it is recommended to consult with fishermen as they will tell you which ones are the most representative of the activity in the sector. The stations will then be evenly distributed along your MPA coastline. At each station at least 2 permanent transects should be marked.

The case of monitoring populations to ensure an environmental watch,

The choice of stations will depend here on your questions (predator-urchin balance, sea urchins impact on algal communities etc.). You can for example compare a station (in the reserve) where fish are protected with a station (outside the reserve) where fishing is permitted. A snorkel survey from the surface will help you identify suitable places to establish transects in stations that you have already selected. It would be interesting to identify and track overgrazing.

Figure 101: Overgrazing

Permanent transects

Each transect will be marked at the beginning and end with steel bars driven into the sediment, by setting a surveyor tag or by setting a simple concrete slab or block. The position of each marking can be taken with GPS.

Each transect will have its own number.

Figure 102: Fixing a marking on the seabed

The length and width of the transects should be established before and will be the same for every transect. We will take here as an example a length of 25 meters and a width of 2 meters (1 meter on each side of the measuring tape). Place a tape measure between the two markings in order to visualise the transect on the seabed.

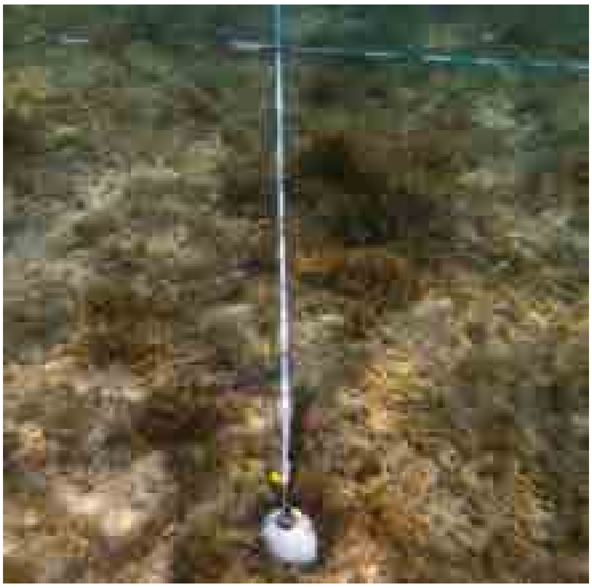

Figure 103: Permanent transect visualised with a measuring tape

Counting

Field protocol

The counts are made using a 2 m rod which is moved along the tape. Each urchin seen along this inventory corridor will be counted and measured. The measurement corresponds to the diameter of the test without spines. Measuring sea urchins can be in two size groups: “superior” or “inferior” with a size limit which can be the minimum catch size. It is advisable to choose a size limit slightly below the minimum fishing size so that the “lower” size is only for unexploited urchins. It is important to only count the urchins that are seen, looking in hollow cavities or turning boulders is not allowed. Counts are made by two divers: one does the survey, counts and measures the sea urchins, the other takes notes. The sea urchins’ size is measured and communicated to the person who is taking notes on the surface.

To account for the aggregative nature of the species, individuals are counted along five sections of 5 meters each.

Figure 104: Surveying along an inventory corridor

Figure 105: Measuring a sea urchin's test

The measurement can be made using a slide ruler or a calliper. Once measured, the urchins are placed back on the seabed where they were discovered.

In the presence of a particularly large population such as in Photo 101, sea urchins will not be brought up to the surface, they will be counted in rapid dives and their size measured by the ruler on the waterproof slate.

To monitor a fished population, it will be necessary to count at the beginning and end of each fishing season. In the case of an environmental watch, counting once a year will suffice.

Characterisation of transects will be done for each 5 meter section:

- depth (beginning and end of the transect),
- orientation,
- nature of the substrate (sand / gravel, rock, meadow, algae and overlapping percentage of each)),
- roughness (in the case of rocky seabeds),
- exposure.

Preparing a waterproof slate

Preparing a table will facilitate the collection of data in the field.

Date					
Transect n°	Test > size limit	Test > size limit	Transect n°	Test > size limit	Test > size limit
0 to 5 m			0 to 5 m		
5 to 10 m			5 to 10 m		
10 to 15 m			10 to 15 m		
15 to 20 m			15 to 20 m		
20 to 25 m			20 to 25 m		
Transect n°	Test > size limit	Test > size limit	Transect n°	Test > size limit	Test > size limit
0 to 5 m			0 to 5 m		
5 to 10 m			5 to 10 m		
10 to 15 m			10 to 15 m		
15 to 20 m			15 to 20 m		
20 to 25 m			20 to 25 m		
…					

Table 12: Example of a table for the collection of field data

Data entry and capitalising on data

Data entry

Data entry can be carried out on a spreadsheet or a DBMS. For a spreadsheet, as always, each line corresponds to new data; each field must be filled in for each row in order to have an effective analysis.

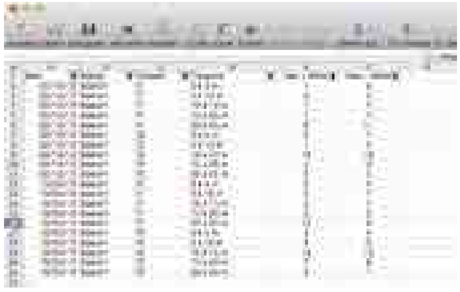

Figure 106: Data entry table

Capitalising on data

Counting urchins in a specific surface area is used to calculate densities, like the average individual density per square meter. Thus on a given date, you can calculate:

- Average Number of individuals per m² = (total number of individuals) / (total surface area sampled)
- Average Number of small individuals m² = (Total of small) / (total area sampled)
- Average Number of large individuals m²= (Total of large) / (total area sampled).

The same calculations can be done at a station level to compare them. Then, you can follow the evolution over time of urchin densities across your study area (e.g. monitoring done by the Blue Coast Marine Park, figure 107).

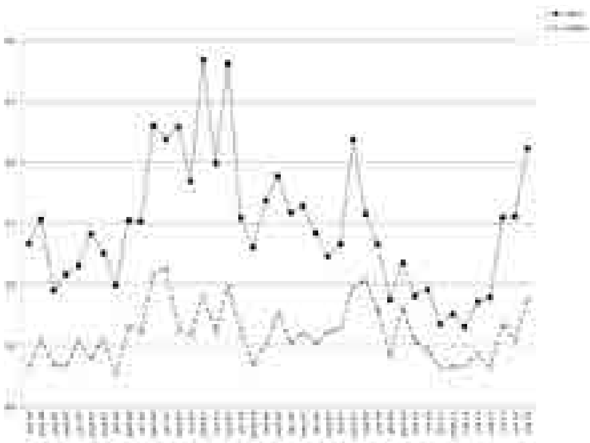

Figure 107: Evolution of the average urchin densities (ind/m²) counted in two size groups (large> 40 mm, small <40 mm) on 5 of Martigues' marine sites (Bachet *et al.*, 2010).

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5. Other methods, other possibilities with snorkelling

The snorkelling tool allows a manager to easily and efficiently have a view of the shallow coastal waters. We will present here a series of examples where snorkelling can be used as part of the MPA's management plan. These examples are less detailed than in the methodology notes because they were not implemented during the project. Methodologies were identified during interviews with managers and scientists and are from studies conducted within MPAs. They are efficient and illustrate the opportunities provided by snorkelling for MPA management.

5.1 Mapping the abundance of algae and invertebrates in the medio-littoral and shallow sub-tidal zones

The edge of the intertidal and shallow sub-tidal zone is subjected to very hostile environmental conditions. Waves and strong variations in temperature, light and salinity are indeed very restrictive, only marine organisms adapted to this type of environment develop there. This zone is prone to anthropogenic pressures such as pollution from land-surface pollution, trampling or exploitation.

The selection of species to be inventoried will be done with the help of scientists in order to identify those that are the most relevant in terms of problems encountered. While in some cases it is possible to visit these sites on foot, in others snorkelling will be essential (for vertical or very steep rock faces).

As an example, here is a list of selected species (table 13) in studies done by the Port Cros National Park (Bagaud Island, Rascas and Gabinière islets, France) and the Bonifacio Strait Nature Reserve (Lavezzi Islands, islets and coastal tip from di u Cappicciolu to Sperone, France).

Fauna	Flora
Cnidaires	**Algues pérennantes**
Actinia schmidti	*Lithophyllum byssoides*
Mollusques gasteropodes	*Cystoseira amantacea* var. *stricta*
Patella ferruginea	*Rissoella verruculosa*
Stramonita haemastoma	*Ulva sp.*
Arthropodes	*Enteromorpha sp.*
Pachygrapsus marmoratus	*Cystoseira compressa*
Eriphia verrucosa	

Tableau 13: List of inventoried species in studies led by Professor Meinesz

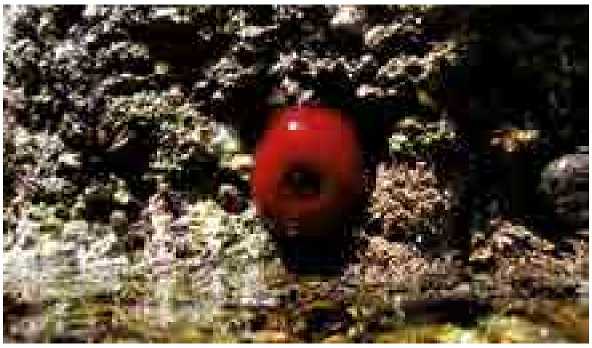

Figure 108: *Actinia equina*

These species are selected for:

- their uniqueness which enables to characterise an environment. For example *Cystoseira amantacea var. stricta* is found mainly on areas exposed to strong hydrodynamics,
- their sensitivity to surface water pollution. *Eriphia verrucosa* and *Pachygrapsus marmoratus* crabs are sensitive to hydrocarbons.
- their nitrophilous character. The significant development of *Ulva sp*. and *Enteromorpha sp*. identifies organic pollution.
- their protection status. For example, *Patella ferruginea* is rare and protected in France.

In these studies, species were identified by allocating abundance groups (for each species) and mapped along a coastline divided into 20 meter sections, on a scale of 1: 1 000.

During the study at Port -Cros in 2001, the linear occupied by macrophytes (Cystoseira *stricta var amantacea, Cystoseira compressa* and *Rissoella verruculosa*) was measured as follows: Class 1 for a 0-5 m coverage, class 2 for 5 to 10 m and class 3 for > 10 m. Chlorophytes (*Enteromorpha sp* and *Ulva sp*) were identified as classes 0.2 to 3 m, 3-5 m and 5 m. Limestone rhodophyte, *Lithophyllum byssoides* were identified as classes: 1-5 m, 5-10 m and 10 m by distinguishing the following formations:

- The isolated fronds (like scattered half spheres and with a small diameter: 3-10 cm),
- Coalescing fronds (forming thin and narrow continuous plating)
- Encrustations (thick plating formed by a continued growth of fronds).

For *Actinia schmidti,* three classes were selected according to their abundance: 1-10, 11-30 and over 30 individuals. There was no distinction between small and large individuals. The largest diameter of each individual *Patella ferruginea* was measured with callipers.

For the *Eriphia verrucosa* and *Pachygrapsus marmoratus* crabs, the total number of individuals observed was identified for each 20m section. The counting of these two species cannot be exhaustive because of their speed and their elusive nature.

Mapping representations obtained thus, provide insights on the distribution and abundance of species and to assess any future impact. Dividing the coastline into sections gives an interesting and precise angle to management.

Figure 109: Port-Cros mapping representations done in 2001 (Meinesz *et al*., 2001)

The presence of tar on the coastal edge is noted for each sector, as is macro-waste.

Date of readings	July 2001
Number of sectors	70
Sector numbers	979 to 1048
Linear total	1392 m
Cystoseira amantacea var. *stricta*	508 m
Cystoseira compressa	3,5 m
Lithophyllum byssoides : - boules, - encrustations	 689 m 98 m
Rissoella verruculosa	789 m
Enteromorpha sp.	4 m
Actinia schmidti	377
Patella ferruginea	1
Stramonita haemastoma	12
Eriphia verrucosa	19
Pachygrapsus marmoratus	67
Tar	1 m
Macro-waste	5 m

Tableau 14: Distribution and abundance of species and parameters recorded on the coast of Gabinière island (Port-Cros, (Meinesz *et al*., 2001))

5.2 Observations on users' impact along an underwater trail

The underwater trail is an environmental awareness-raising and educational tool that allows many people to discover the wonders of shallow coastal waters.

If an underwater trail cannot be put in place, then a guide might step in to talk about the species encountered and supervise users so that they adopt a respectful behaviour towards the seabed. The guide may not consistently follow the same route and may even change site as appropriate. In this case, the impact on the seabed will be limited.

In the case of an underwater trail where users discover the seabed without supervision, the situation can become more problematic. If the trail is to show a route where marine resources are preserved, the trail will result in a convergence and increased attendance in a specific place and could adversely affect species and habitats. It is crucial to initially choose a site which is deep enough so that users are not tempted to stand for example.

In situ snorkelling observations can be made by an MPA agent to identify problematic actions most commonly made by users and thus adapt the management of the trail and make recommendations to users.

As an example, here is the protocol done for the Cerbère-Banyuls natural reserve's underwater trail (Payrot *et al.* 2009). During the summer season, a reserve agent took 45 minutes to visit the underwater trail, several times a day. For each type of users; a swimmer, a snorkler, FM snorkel (specific Banyuls Reserve Trail equipment) or scuba diver, the agent noted down the following actions: hand, fin strokes, foot resting, vertical kicking, pebbles moving, feeding, little fishing, collection, disturbance of animals, underwater photography.

The results of this monitoring, shown in Figure 110, allowed the reserve's managers to adapt the supervision of users and awareness messages emphasizing the actions identified during monitoring.

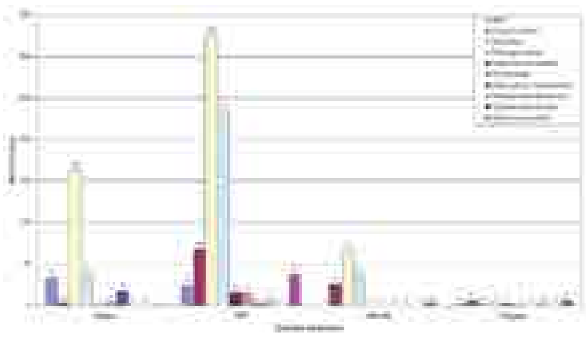

Figure 110: Distribution of impacts by type of users (Swimmer, Snorkeler, FM snorkel, Diver) - Peyrefite Underwater Trail (Paytot *et al.*, 2009)

Figure 111: Snorkeler standing (© Réserve Cerbère-Banyuls)

5.3 Collection of biological material or sediment

The *Ostreopsis ovata* ecological watch

Some monitoring require the collection of marine species. This is the case for the study of microscopic algae, *Ostreopsis ovata*. This non-native species of tropical origin grows in the Mediterranean and sometimes in such concentrations that it can cause health problems.

This epi-benthic species grows on rocky substrate or macrophytes. The accumulation of *Ostreopsis ovata* toxins in the urchins' tissues was studied at several sites on the French coast. For this, *Paracentrotus lividus* sampling by snorkelling are done regularly in places identified as favourable to the development of this species. As required, samples of water and macrophytes are also taken.

Figure 112: Diver collecting sea urchins

Sediment sampling

Doing core sampling is quite possible by snorkelling. It can be done in quite deep waters depending on the diver's capabilities. One should note that the use of a ballast (which can just be a plumbline attached to a cord) would facilitate the diver's descent. The ballast is raised once the diver goes back up to the surface.

The core is made from a plexiglass tube and closed by the diver at the bottom with a cork.

Figure 113: Diver going down with a ballast

5.4 Census of macro-waste on the seabed

The presence of macro-waste on the seabed can damage species and habitats, depending on their polluting nature or not and their location, but also harm sea users (swimmers, leisure boat users and fishermen). In view of their volume, weight and nature, some waste cannot be disposed of by snorkelling, or even diving. An accurate survey of these wastes and in view of their nature and budget available, areas to be cleaned will be prioritised and a company specializing in the removal of waste for the most problematic. Please note that some waste does not need to be removed if it is non-polluting, it has been there a long time and is heavily concreted.

Figure 114: Boat battery, a highly pollutant waste

Figure 115: Inert and concreted waste

A snorkel survey from the surface can be quickly done for the entire coastline. The clarity of the water will determine the maximum depth waste can be detected.

Surveying can be done with fins and a towed raft to carry the necessary equipment: waterproof slate, camera, lead weighted rope, tape measure. This kind of survey can also be done with a boat that pulls the diver along.

Here is information that should be noted for each waste found:

- description of the waste: cable, dead body, tyres, battery, etc.,
- photo: take one or two shots and take down the number,
- size: estimate,
- pollutant: yes or no,
- concreted: yes or no,
- depth: given by a lead weighted rope, a depth or boat sensor,

- substrate: sand, seagrass, rock etc.,
- GPS coordinates: taken directly above the waste,
- place: name of the inlet, bay, or the nearest point.

5.5 Non-native species, detection and inventory

Some non-native species can become invasive under certain conditions. In fact, they have good conditions to grow in their new environment without any other limiting factor. Managers are often defenceless against these complex phenomena which are difficult to stop.

Their identification, signalling them to specialist networks and monitoring their development is very useful to improve the understanding of the mechanisms involved and educate users who are likely to participate in their expansion without realising. An important reflex should be to find out from networks when a new species appears near your MPA.

Surveying shallow waters helps to note the presence or absence of invasive species. A closer monitoring may be undertaken in view of the problems encountered.

Below, are two databases synthesizing knowledge about non-native and invasive species:

- Delivering Alien Species Inventories for Europe (DAISIE) http://www.europe-aliens.org,
- Atlas of exotic species in the Mediterranean. The Mediterranean Science Commission (CIESM) http://www.ciesm.org.

Monitoring marine invasive species in marine protected areas (MPAs) in the Mediterranean; a practical and strategic guide for managers

This book edited by MedPAN provides an overview on the distribution and invasiveness of different non-native Mediterranean species.

We invite you to refer to it to establish a monitoring and reporting protocol within your MPA. Snorkel field campaigns can be carried out in your MPA's shallow waters. The figure below shows the black list of invasive marine species in the Mediterranean which is given in this guide. This list provides the most problematic species whose identification can be performed by non-specialists. These species can be targeted in a monitoring and surveillance programme.

Figure 116: Black list of invasive species in the marine environment (Otero, M. *et al.*, 2013)

An identity card for each species is given and has the following information:

- Key identifying characteristics,
- Habitat and identification elements on the ground,
- Reproduction,
- Brief history of its introduction and its access route,
- Ecological impacts,
- Economic impacts,
- Management options,
- To learn more.

The figure below shows an example of an identity card from this guide.

Figure 117: *Percnon gibbesi* crab ID Sheet

The MedPAN collection

The MedPAN collection is a series of tools and user-friendly guidebooks that can provide guidance and build capacity on key issues that managers of Marine Protected Areas (MPA) in the Mediterranean have to confront daily.

The MedPAN collection is fully adapted to the Mediterranean context and is peer reviewed by MPA managers and experts of the region. It gathers tools and guidebooks developed by key players in the Mediterranean under a unified look and feel.

The MedPAN collection is an initiative of several Mediterranean partners, including RAC/SPA, WWF, IUCN Mediterranean, MedPAN, ACCOBAMS, the French Biodiversity Agency and the Conservatoire du littoral. It is edited by MedPAN, the network of MPA managers in the Mediterranean.

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