EUROPEAN COMMUNITY - DG XIV

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Project MED93/007 - FINAL REPORT

EFFECTS OF SKID TRAWL FISHING ON SHALLOW *POSIDONIA OCEANICA* MEADOWS AND THE BENTHIC COMMUNITIES IN NORTH-WESTERN SICILY

CONSIGLIO NAZIONALE DELLE RICERCHE

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Mazara del Vallo (ITALY)

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Scientific team: *Maria Teresa Accardo Palumbo & Carlo Pipitone*
Technical team: *Gianfranco Scotti & Daniela Bianca*

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PREAMBLE

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This study has been carried out with financial assistance from the Commission of the European Communities.

CONTENTS

4 DISCUSSION

4.1 The skid trawl net impact on the shallow *Posidonia oceanica* system

4.2 Impact on the plant

4.3 Impact on the associated organism

5 CONCLUSION

6 REFERENCES

LEGEND OF THE PHOTOS

Photos 1-2 - The experimental skid trawl used in this study

Photo 3 - The experimental skid trawl used in this study

Photo 4 - Professional skid trawl nets

Photo 5 - Professional skid trawl nets

Photo 6 - Hand-towed net collection of *Posidonia oceanica* vagile fauna of leaf stratum

Photo 7 - The skid trawl net while fishing: a mouth view

Photo 8 - The skid trawl while fishing: a cod end view

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Running title: Skid trawl fishing on shallow *Posidonia oceanica* beds in NW Sicily.

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ABSTRACT

This report is aimed at evaluating the effects of the skid trawl (in Italian "gangamo") fishing on shallow *Posidonia oceanica* beds and on the associated benthic community in north-western Sicily. The skid trawl is a particular dredge illegally used to catch prawns (especially *Palaemon* spp.) to be used as a bait in hook-and-line fishing, as well as edible sea urchins (*Paracentrotus lividus*) on shallow *Posidonia oceanica* meadows. The use of this gear, as well as any other bottom-trawled fishing gear, is forbidden by Italian laws at depths lower than -50m.

A pre-survey was carried out along the north-western Sicilian coast, where *P. oceanica* meadows are known to be widespread. This area includes two provinces: Trapani and Palermo. In all the fishing towns and villages belonging to these districts interviews were made to sports and professional fishermen, in order to assess the presence of the skid trawls, their features and their use.

As a second step an extensive sampling survey was carried out near Mazara del Vallo, since it appeared from the pre-survey to be the largest skid trawl fishery among those investigated. Two sampling sites were chosen:

a) Tonnarella, near the main harbour of Mazara del Vallo, as a study site, since an intense local fishing activity was pointed out in the pre-survey;

b) Capo Feto, a little farther westwards, which was a much less intensely exploited area.

The sampling strategy carried out in the two sites included:

1 - measurement of the *P. oceanica* shoots density;

2 - evaluation of the main phaenological parameters of the seagrass: number of leaves per shoot and per m², leaf area index (LAI) and leaf surface index (LS) (showing respectively the average surface of leaves per m² and per shoot), and coefficient *a* (percentage of broken leaves);

3 - nightly underwater sampling of the leaf stratum vagile fauna using the hand-towed net method;

4 - nightly experimental skid trawl tows;

5 - assessment of the direct impact of the skid trawl, by a visual technique performed during the day.

Point 1 was carried out only twice, point 5 was done once in each site; the remaining points were performed monthly. Each treatment included replicates and was statistically tested.

The *P. oceanica* parameters were analysed using the Giraud (1977) classification in age classes. Molluscs and decapod crustaceans were always identified at the species level, while echinoderms and fish were identified at the species level in the skid trawl samples. The community structure was assessed by means of some indices (species richness, diversity, dominance and evenness). Statistical comparisons were made between the sites and within each site on a seasonal scale. The effects of skid trawling on the *P. oceanica* system was assessed by comparing the amount of seagrass experimentally harvested with the skid trawl with its standing crop, as well as comparing the amount of vagile fauna of leaf stratum collected with the skid trawl with its real density, estimated by the hand-towed net method.

In 15 towns out of 36 investigated the skid trawl was more or less intensely used. In two more localities the gear was likely to be used, but it was impossible to obtain true information due to the highly suspicious attitude of fishermen. The lightest gears weighed about 7-10 kg, the heaviest up to 50 kg.

The average shoot density was significantly higher in the control site of Capo Feto, as well as the average number of leaves per m^2. Generally all other phaenological parameters did not differ significantly between the two sites.

The analysis of the composition of the skid trawl samples showed that *P. oceanica* leaves and *matte*, both live and dead, accounted for more than 50% of the total catch in both sites. The other main items harvested were echinoderms (more abundant at Tonnarella), crustaceans, fish and algae.

The average weight of each haul ranged from 4 to 34 kg (76 to 550 kg/ha), depending on the catch composition and in particular on the amount of seagrass and sea urchins.

The statistical comparison between the phaenological parameters, the structure and composition of the vagile fauna of leaf stratum and the skid trawl yields of the two sites showed that there was a higher variability within each site (due to the seasonality) than between the two sites.

The impact of skid trawling on shallow *P. oceanica* meadows was evident in every portion of the plant (leaves, rhizomes and *matte*) as well as in the associated fauna of both leaf and rhizome strata. Despite the gear impact, well evident from the skid trawl catch, the underwater observations did not show any significant and visually appreciable damage to the plant. Calculating the percentage of live leaves and shoots collected by the skid trawl with respect to their standing crop *in situ*, only a small amount of plant, generally less than 0.1%, was collected by the gear. The percentage of leaf stratum vagile fauna collected with respect to its density was slightly larger instead, with a maximum for *Pagurus anachoretus* (11% at Tonnarella and 60% at Capo Feto) and *Bittium reticulatum* (35% at Capo Feto). The impact on the fauna of the rhizome/matte stratum was not assessed, since the evaluation of density for this assemblage as well as for the fish assemblage is very complicated. The average number of decapod and mollusc species of rhizome/matte stratum was however greater than that of leaf stratum, even if this ratio was inverted for the number of specimens.

Though the skid trawling impact is evident on the whole *P. oceanica* system, it seems greater on the fauna than on the plant. Due to the importance of the *P. oceanica* ecosystem in the Mediterranean Sea, a greater care should be taken in order to stop this illegal fishing technique in Sicily.

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SYNTHESIS FOR NON-SPECIALISTS

The *Posidonia oceanica* ecosystem may be considered one of the most productive environments in the benthic domain of the Mediterranean Sea. Because of its importance many Mediterranean countries have adopted acts in order to protect the meadows. The inshore illegal trawling is considered one of the main enemies of this seagrass.

P. oceanica is a macrophyte belonging to the class of Angiosperma. The plant is made up of a rhizome, leaves and roots. It is widespread in the whole Mediterranean Sea from a depth of a 1m up to 40m, with the exception of the middle and upper Adriatic Sea. Each rhizome produces about seven leaves per year, and it grows horizontally or vertically depending on the different environmental conditions. One rhizome with its leaves and roots makes a shoot. The complex made up of rhizomes, roots, sediment and organic debris is called *matte*, and may attain a thickness of several hundred centimetres. *P. oceanica* lives and grows on different substrata including sand, rock and *matte*.

In north-western Sicily a particular skid trawl called "gangamo" is employed by fishermen on shallow *P. oceanica* meadows to catch prawns (especially *Palaemon* spp.) to be used as a bait in hook-and-line fishing, as well as edible sea urchins (*Paracentrotus lividus*). This gear, as well as any other bottom-trawled fishing gear, is forbidden by Italian laws at depths lower than -50m.

The skid trawl is a sort of a dredge made up of two iron semicircles joined together at an angle of 90° to form the frame of the opening, which is low in height in comparison with its width (about 80 cm). The average weight ranges from about 7 to 50 kg. While fishing, the gear shakes the seagrass leaves from the base, collecting the organisms living on both the leaf and the rhizomes. About 80 skid trawls of different shape and size were censused in our pre-survey in the provinces of Palermo and Trapani, notwithstanding the strong suspicions of local fishermen.

In order to assess the impact of skid trawling on the shallow *P. oceanica* beds and on the associated benthic communities, an extensive sampling survey was carried out near Mazara del Vallo, where a huge *P. oceanica* meadow stretches from the harbour several miles westwards. The area of Tonnarella, commonly exploited by skid trawlers, was chosen as a study site and that of Capo Feto, much less intensely exploited, as a control site. During the survey the main characteristics of the two meadows were studied, including the shoots density (*i.e.* number of shoots per m^2), as well as other specific parameters. In the two sites monthly experimental skid trawl tows were made to evaluate the direct impact of the gear. At the same time the vagile fauna of leaf stratum was collected using a hand-towed net. Some underwater observations of the direct impact of the gear on the meadows were also carried out.

The shoots density was higher at Capo Feto (787 shoots/m²) than at Tonnarella (487.5 shoots/m²); as a consequence also the number of leaves per m² was higher at Capo Feto. The other parameters measured on the leaves did not differ very much between the two sites.

The hand-towed net harvested a total of 18321 specimens at Tonnarella and 26252 at Capo Feto. The most abundant zoological groups were amphipods, gastropods, isopods, decapods, copepods and ostracods.

The experimental skid trawl tows yielded generally larger catches at Tonnarella. The dead and living *P. oceanica* leaves and *matte* made up the bulk of each haul in the two sites. These items accounted for about 60% of the total catch at Tonnarella and about 75% at Capo Feto. As for the animal component, echinoderms (mostly sea urchins) were the dominant item (82% at Tonnarella, 50% at Capo Feto).

In general no significant difference was found between the two sites, with the exception of a higher shoots density at Capo Feto (which is the less exploited area), and higher sea urchins yields at Tonnarella (which is the most exploited one). The variation within each site (due to seasonality) was instead high.

Skid trawling effects are evident on the whole *P. oceanica* ecosystem. The vagile fauna of leaf stratum is probably the most heavily affected item, and the impact on it seems greater than on the plant. The average percentage of specimens harvested by the skid trawl ranged from less than 1% up to 60% of the total number of specimens living *in situ*, as estimated by the hand-towed net method. Unfortunately the same estimate may not be extended to the fauna of rhizome stratum and to the fish fauna, since a reliable sampling of these components is very complex and time consuming.

Due to the importance of the *P. oceanica* ecosystem in the Mediterranean Sea, a greater care should be taken in order to stop this illegal fishing technique in Sicily.

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1 - INTRODUCTION

Sicily was, and still is, an area where fishermen use a special skid trawl called "gangamo" or "gangamello" on shallow *Posidonia oceanica* meadows, in order to catch prawns (especially *Palaemon* spp.) to be used as living bait, as well as edible sea urchins (*Paracentrotus lividus*). The gear is similar to those described and used for scientific purposes by Bell & Harmelin-Vivien (1982), Chessa (1984) and Harmelin-Vivien (1981). This fishing technique is supposed to exert a mechanical damage on the seagrass bed, and to cause an impoverishment of the biotic assemblage. For this reason the use of the skid trawl, as well as of any other trawling gear, is forbidden by Italian laws (D.P.R. 2/10/68 n.1639) within the -50m isobath or within a 3 miles distance from the shoreline. Anyway the same act provides for the possibility of exploitation of seaweeds and seagrass.

This study was aimed at evaluating the damage produced by skid trawling on shallow *P. oceanica* meadows along the north-western coast of Sicily. For this purpose, experimental fishing surveys were carried out, along with an analysis of the phaenological parameters of the seagrass and studies on the associated vagile fauna.

1.1 - GENERAL REMARKS ON *POSIDONIA OCEANICA*

Posidonia oceanica is considered one of the most productive macrophytes in the Mediterranean Sea (Ott, 1980). The leaf production of this seagrass ranges from 310 to 1540mg dry wt shoot^{-1} yr^{-1}, depending on site and depth (Pergent-Martini *et al*., 1994). Although only a few species are able to consume directly the plant (Den Hartog, 1980), the energy accumulated by it plays a fundamental role in many food webs (Lawrence et al., 1989), as reported in many papers concerning the trophic role of the vagile fauna living in *P. oceanica* beds (Bell & Harmelin-Vivien, 1983; Chessa *et al*., 1989a, 1989b; Coulon, 1992; Fresi *et al*., 1984; Mazzella & Russo, 1989). *P. oceanica* also plays a role in fisheries and as a nursery ground (Harmelin-Vivien, 1983; Matricardi *et al*., 1992).

A regression of *P. oceanica* beds was recorded during the last decades (Ardizzone, 1992) as a result of human activities along the coast. Also fishing activities have contributed to the impoverishment of the meadows, particularly inshore bottom trawling (Ardizzone & Pelusi, 1984; Orru, 1990).

1.2 - *POSIDONIA OCEANICA* MEADOWS IN SICILY

Posidonia oceanica meadows are widespread along the north-western Sicilian coast (Toccaceli & Riggio, 1989), where they cover a large area of sea bottom down to

40m. The greatest development in terms of density and percent covering is attained along the western Sicilian coast in the Trapani area (Figg.1-2).

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2 - MATERIALS AND METHODS

The research protocol was made of three points:

- a **pre-survey** aimed at knowing the distribution of the skid trawl along the north-western Sicilian coast, its use by fishermen and its general features and characteristics. Moreover the pre-survey was aimed at designing and constructing a skid trawl to carry out experimental fishing and at assessing the duration of the tows to be made. A third aim was to choose the sampling sites and to estimate the average shoot density of *P. oceanica*, which is one of the main parameters in any study of seagrass beds;
- an **experimental survey** aimed at assessing the effects of skid trawling on the shallow *P. oceanica* system through monthly sampling including: a) collection of shoots; b) collection of the vagile fauna of leaf stratum by means of a hand-towed net and of a skid trawl;
- the **data analysis**.

2.1 - PRE-SURVEY

The pre-survey was carried out along the north-western Sicilian coast (Fig. 1). It started in February 1994 and lasted about six months. The available bibliographic references (ICRAM, 1989; Toccaceli & Riggio, 1989; Toccaceli & Alessi, 1989; Toccaceli, 1990) concerning the area were consulted, in order to assess the distribution of the *P. oceanica* meadows (Fig. 2) and the main features of the small scale fisheries. All the coastal towns and villages in the area were pooled in two groups according to the province they belonged to (Fig. 3). The first group (province of Palermo) included Trabia, San Nicola, Porticello, Santa Flavia, Sant'Elia, Aspra, Bandita, Sant'Erasmo, Cala, Acquasanta, Arenella, Vergine Maria, Mondello, Sferracavallo, Isola delle Femmine, Carini, Terrasini, Trappeto and Balestrate. The second group (province of Trapani) included Mazara del Vallo, Petrosino, Torrazza, Biscione, Torre Scibiliana, Punta Parrino, Marsala, Sappusi, Spagnola, Mozia, Stagnone, Nubia, Marausa, Trapani, San Cusumano, Bonagia, San Vito Lo Capo and Castellammare del Golfo. Lastly an investigation was carried out in order to assess if, and to what extent, the skid trawl is used by fishermen. After this preliminary phase, interviews to fishermen were carried out in each of the above mentioned localities.

This strategy proved to be very useful, because it has been easier to interview the fishermen once several data regarding the fisheries and the use of the skid trawl had been acquired. In many cases this helped us to overcome the reticence and suspicion we met with almost everywhere. For the same reason, we put our questions mostly to old

retired fishermen or to people not directly involved in fishing activities. The main questions are reported in Questionnaire 1.
The information gathered during the pre-survey led us to choose Mazara del Vallo as our sampling area (Fig. 4). The reason was that in this zone skid trawl fishing is intensely practised on a wide *P. oceanica* bed; moreover, a much better organisation of the sampling operations was allowed by the presence of our Institute in town. An extensive investigation, both on the use of the gear and on the characteristics of the seagrass bed, was thus carried out.
The Mazara del Vallo skid trawl fishery extends westwards as far as Capo Feto (Fig. 4). Two sampling sites were chosen: the first one off Tonnarella, the second one off Capo Feto (Fig. 5). From our pre-survey Tonnarella appeared to be the most intensely exploited area, because of its closeness to the Mazara del Vallo harbour. The shallow *P. oceanica* bed off Tonnarella (**TO**) was thus chosen as study site, the one off Capo Feto (**CF**) as control site.
The information collected allowed us to give a general description of the skid trawl used in north-western Sicily and to design an experimental one.

2.1.1 - Sampling sites description

2.1.1.1 - General features

The centre of the area under examination lies approximately at 38°40'N and 12°33'E. Capo Feto is a Pleistocenic sandstone outcrop: it may be defined as a low flatland whose nature is a carbonate fossiliferous sandstone, dating back to the middle-lower Pleistocene.
The mainland is a low-lying salt marsh, the remains of a pristine wetland, partially drained in the last few decades. In the eastward direction the sandy beach of Tonnarella stretches up to the first docks of the harbour of Mazara del Vallo.
Some traces of a previously existing ancient sand bar, destroyed by man's action, are evident in the back shore of the western side of the area.
The sea ground off Capo Feto has a stepwise profile characterised by a sequence of rocky erosion terraces at increasing depths. The deepest ones lie at -5m, and mark the outer edge of a submerged shore, whereas the shallowest reach the shoreline.
Luxuriant seagrass beds grow on the rocky platforms which make up the littoral strips, as well as on the bioclastic and terrigenous sands carpeting the low-lying terraces. The Bay of Tonnarella is a beach with a sandy bottom on the west side and again luxuriant *P. oceanica* beds on the east side.

***2.1.1.2** - Littoral area*

The submerged beach is made up of middle-sized sand, whose main component is quartz. A stream-ridge showing a linear pattern and a second order cresting are visible within a 100m offshore distance. This is an evidence of marked instability of the sand and of high availability of a sedimentary stock. Evidence of a recession of the Capo Feto shore, due to erosive regression, is provided by the emergence of the sandstone front platform. This is a residual high ground, stretching W-E, marked offshore by a low ledge.

The platform and the erosive terraces support a luxuriant *P. oceanica* stand, *i.e.* the so-called "*récif-barrière*", almost reaching the water surface.

Both the stream-ridge and the littoral rows of dunes caused by the accumulation of seagrass leaves indicate a W-E coastal drift; an area of intense silting is created by secondary flow lines just leeward of Capo Feto.

***2.1.1.3** - Seagrass beds*

Posidonia oceanica beds thrive very close to the sea surface. The stand nearest to the coast settles on the littoral erosion platforms; its upper limit often coincides with the edge of the rocky shore. Seagrass beds are replaced by reef-formations (the *récif-barrière*) at depths greater than -3m.

The main *récif* has a linear development marking the uppermost border of the seagrass bed *sensu stricto*. Different aspects of the *récif-barrière* namely ringed-reefs, island-like-reefs and the like are observed on nearshore bottoms. The original bedrock and dead *"mattes"* occur on the bottom of the *"intermatte"* trenches at less than -5m, whereas the *intermattes* at greater depths are often filled up with bioclastic debris.

The abrupt lower limit of the seagrass bed lies at a depth of 23-25m. This limit is marked by a step of the *matte*. *P. oceanica* "islands" and dead *mattes* however attain -27m, irregularly scattered over the sandy bottom, showing a high morphological diversity.

The reef structure is interrupted at the western corner of the Bay of Tonnarella by the homogeneous sandy bottom.

2.1.2 - The skid trawl - General features and characteristics

The fishing gear called in Italian "gangamo", for which the English term "skid trawl" was recently used (Harmelin-Vivien, 1981), is basically a dredge with a fixed opening, used to fish on shallow *P. oceanica* meadows.

Two iron semicircles (or one semicircle and a rectangle with one sides missing) are welded at an angle of 90° to form the frame of the opening, whose height is low in comparison with its width (Photos 1-3). The vertical part of the frame forms the true opening, while the horizontal part "skids" on the bottom. Sometimes one single iron rectangle bent to form an angle of 90° at about half of its length is used for the frame. The collecting bag is made of a net formed by two distinct sections, an "anterior" and a "posterior" one. They differ for the mesh size and number as well as for the material used (type of net yarn and netting). The mesh number decreases from the anterior to the posterior part.

The upper part of the net (top belly) is called "cielo", while the lower (belly) is called "tassello".

The lower ends of the opening frame bring two iron rings connected to chains which are joined to strong ropes ending up in a single trawl warp.

Apart from the above mentioned characteristics, the shape of the "gangamo" can vary quite a lot, since this fishing gear is locally manufactured by fishermen or by local craftsmen using different kinds of materials, often depending on what is available. The construction of the gear varies also according to the type of substratum on which the seagrass grows (sand, rock or *matte*), to the thickness of the meadow, to the depth and to the target species (prawns or sea urchins).

2.1.3 - The skid trawl - Characteristics of the experimental gear used in this study

A "gangamo" with the characteristics of those more commonly used by fishermen in Mazara del Vallo was built. Its features are the following (Photos 4-5):

- the frame is formed by an iron trapezium with a major base of 102cm, a minor base of 92cm and sides of 172cm. This was bent to form an angle of 90° at a distance of 65cm from its major base (Fig. 6). At the lower ends of the opening there are two iron rings ("golfari") 9cm in diameter, to which two iron chains of about 0,5 kg each are attached for ballast. The frame plus the chains weigh about 40 kg;
- a polyamide rope 17mm in diameter, 4.1m long, is attached to each chain. The ropes end up in a trawl warp 35m long and 22mm thick;
- the anterior part of the net is long 2.25m, the posterior one 2.55m. An additional piece of netting is attached under the lower part of the net, to protect it form the bottom roughness;
- the upper part of the net ("cielo") brings 275 meshes, the lower one ("tassello") 47;
- mesh side length and mesh length were measured according to UNI M8 (1988).

The characteristics of the whole fishing gear are summarised in table 1.

2.1.4 - Vessel characteristics

The vessel used for the skid trawl fishing had the following features: total length 9.2m, gross tonnage 5.1t, net tonnage 3.4t, power engine 60 hp. The vessel was provided with GPS, echo sounder and hydraulic winch.

2.1.5 - Preliminary skid trawl tows

In May 1994 some preliminary skid trawl tows were made, in order to asses the gear efficiency and the duration of the experimental tows. The duration was established following the criterion of achieving a *plateau* in the cumulative number of decapod species collected with increasingly longer tows. Three different durations (10, 20 and 30 minutes) were tested. The 10-min tow yielded a low number of species and specimens; the 30-min tow yielded the same number of species (though represented by a large number of specimens) than the 20-min tow. Thus the standard duration adopted was 20 minutes.

2.1.6 - Estimate of the mean density of *Posidonia oceanica* shoots

In June 1994 a sampling survey aimed at the assessment of the meadow's density was carried out in the two sites. Three stations were drawn along two transects (one in each site: see chapter 2.2). The number of shoots included within a 20x20cm frame randomly placed in six different points of each station was counted. Data were expressed as number of shoots (*i.e.* mean value of the six replicates) per square meter. The same calculation was repeated in autumn (October 1994), when the lower number of leaves and the reduced overall dimension of the plant allowed a more precise estimation. In the results (chapter 3.2) we will refer to the autumn estimate, while for the interim report the June data were employed.

2.2 - SAMPLING PROGRAMME

A 800m long transect parallel to the coastline was set at an average depth of 3m in both sampling sites (study site of Tonnarella and control site of Capo Feto); it was divided in nine equidistant sampling stations (Fig. 5). The transect placed at Capo Feto started at 37°40'00N and 12°30'62E and ended at 37°40'18N and 12°30'18E. The transect placed at Tonnarella started at 37°39'36N and 12°33'98E and ended at 37°39'12N and 12°34'39E. The position of the transects and of each station was recorded by means of a GPS aboard the vessel. All the sampling operations were carried out along these transects.

The sampling programme aimed at knowing the *P. oceanica* phaenological parameters by means of shoots collections, and the vagile fauna of leaf stratum by means of the hand-towed net method. Along the same transects also experimental skid trawl surveys were carried out. The data obtained in this way were used for comparing the community structure and the *P. oceanica* parameters in the two sites.

2.2.1 - Collection of *Posidonia oceanica* shoots and study of the phaenological parameters.

Samples were collected monthly in each site for one year. A sample of at least two replicates made up of twenty *P. oceanica* shoots was collected along each transect. In all 11 monthly samplings were carried out from June 1994 to July 1995 and a total of 52 replicates was made.

Samples were collected in the following dates:

29/06/94 considered as a spring sample in the seasonal analysis;
26/07/94 considered as a summer sample in the seasonal analysis;
06/09/94 considered as a summer sample in the seasonal analysis;
28/09/94 considered as an autumn sample in the seasonal analysis;
03/11/94 considered as an autumn sample in the seasonal analysis;
29/11/94 considered as an autumn sample in the seasonal analysis;
02/02/95 considered as a winter sample in the seasonal analysis;
17/03/95 considered as a winter sample in the seasonal analysis;
04/04/95 considered as a spring sample in the seasonal analysis;
08/06/95 considered as a spring sample in the seasonal analysis;
07/07/95 considered as a spring sample in the seasonal analysis.

The leaves of each shoot were separated into three age classes, according to the adult, intermediate and juvenile age classification of Giraud (1977), and then counted. The following data were recorded: length and width of all leaves, length at the base (non-photosynthetic portion) of adult leaves and status of the tip (unbroken**,** broken, grazed) of adult and intermediate leaves.

The following phaenological parameters were calculated starting from data recorded on a suitable form (Fig. 7):

- total number of leaves per shoot and per m² for each age class;
- average number of adult (La), intermediate (Li) and juvenile (Lj) leaves per shoot and per m²;

- average leaf area index LAI (Giraud *et al.*, 1979), which expresses the leaves surface per unit area, calculated for adult (LAIa), intermediate (LAIi), juvenile (LAIj) and overall leaves (total LAI):

$$LAI = \text{leaves surface (in m}^2\text{)/bottom surface (1m}^2\text{)};$$

- leaves surface index LS, calculated for adult (LSa), intermediate (LSi), juvenile (LSj) and overall leaves (total LS) in cm²:

$$LS = \text{total leaves surface per shoot};$$

- coefficient *a* = percent number of broken leaves, calculated as global *a* (Ag) for adult and intermediate leaves together, and as specific *a* for adult (Aa) and intermediate (Ai) leaves (Giraud, 1977).

2.2.2 - Collection of the vagile fauna of leaf stratum

Two replicate samples of vagile fauna were monthly collected, between June 1994 and July 1995, in each station during the night (a few hours after sunset) in the following dates:

01/07/94 considered as a spring sample in the seasonal analysis;
26/07/94 considered as a summer sample in the seasonal analysis;
07/09/94 considered as a summer sample in the seasonal analysis;
28/09/94 considered as an autumn sample in the seasonal analysis;
03/11/94 considered as an autumn sample in the seasonal analysis;
29/11/94 considered as an autumn sample in the seasonal analysis;
02/02/95 considered as a winter sample in the seasonal analysis;
08/03/95 considered as a winter sample in the seasonal analysis;
03/04/95 considered as a spring sample in the seasonal analysis;
04/05/95 considered as a spring sample in the seasonal analysis;
08/06/96 considered as a spring sample in the seasonal analysis;
07/07/95 considered as a spring sample in the seasonal analysis.

Samples were collected using a hand-towed net (made of a rectangular metal frame measuring 40x20cm with a net of 400µ mesh size) by SCUBA divers (Photo 6), according to the technique described by Ledoyer (1962) modified and standardised by Russo *et al.* (1985) and Russo & Vinci (1991).

This technique consists of a series of sixty strokes delivered in order to shake the seagrass leaves vigorously from the base of the shoots (Russo *et al.*, 1985). The method is semi-quantitative, thus allowing the samples to be compared, since 60 strokes are equivalent to 19 m^2. The specimens collected were sorted in taxonomic groups and counted in the laboratory. Only molluscs and decapod crustaceans were identified at the species level.

2.2.3 - Skid trawl tows

Two replicate tows were monthly made during the night in each site between June 1994 and July 1995 in the following dates:

29/06/94 considered as a spring sample in the seasonal analysis;
26/07/94 considered as a summer sample in the seasonal analysis;
06/09/94 considered as a summer sample in the seasonal analysis;
28/09/94 considered as an autumn sample in the seasonal analysis;
03/11/94 considered as an autumn sample in the seasonal analysis;
24/11/94 considered as an autumn sample in the seasonal analysis;
17/01/95 considered as a winter sample in the seasonal analysis;
20/03/95 considered as a winter sample in the seasonal analysis;
03/04/95 considered as a spring sample in the seasonal analysis;
04/05/95 considered as a spring sample in the seasonal analysis;
08/06/95 considered as a spring sample in the seasonal analysis;
07/07/95 considered as a spring sample in the seasonal analysis.

The boat speed was recorded every 5 minutes in order to get a mean value, and the swept area was thus calculated. Weight of leaves (including rhizomes), of living and dead *matte*, of algae and of the main animal taxa, as well as the overall weight, were recorded for each haul. The percent contribution of the green portion (*i.e.* living portion of the leaf or living leaves) and of the brown portion (*i.e.* dead portion of the leaf or dead leaves) to the total weight of leaves was calculated by weighing the two fractions.

Living and dead *P. oceanica* leaves and *matte*, algae, animal taxa and non living substratum (detritus and rocks) were sorted out, counted, measured and weighed individually (with the exception of colonial and vegetal organisms which were pooled). Only decapod crustaceans, molluscs, echinoderms and fishes were identified at the species level.

Data were standardised in kg/ha after the calculation of the swept area.

2.3 - DIRECT INVESTIGATION OF THE PHYSICAL EFFECTS OF SKID TRAWLING ON THE SEAGRASS MEADOW

In order to verify the physical impact of the gear on the seagrass meadow, two surveys were carried out in each site, the first in December 1994 and the second in July 1995 during the day. A 200 meters long skid trawl tow was made in both sites. A buoy was thrown about every 10 meters from the boat in order to mark the skid trawl path. In the same time two SCUBA divers were patrolling the area around the trawled transect in order to take photos of the gear in action. After the tow ended, the divers started to make accurate observations on the meadow in the area swept by the gear and marked by the buoys. They looked for damaged shoots or broken leaves left on the bottom, recording these data along the 200 meters path. At the end, the shoot density in the trawled area and in a control area located a few meters off the path was calculated in the same way described in chapter 2.1.6.

2.4 - DATA ANALYSIS

- *Community structure indices*

Five indices were chosen in order to characterise the structure of the zoobenthic community sampled in each site by means of the hand-towed net and of the skid trawl. The indices, along with the number of specimens (No.) of each species, were calculated for each sampling.

Species richness was calculated as number of species (S) and as Margalef index (d' = S-1/ln N; Margalef, 1958), where N is the total number of specimens in the sample. The following indices were also computed:

Simpson dominance index:

$$\lambda'' = \sum_{i=1}^{S} \frac{n_i(n_i - 1)}{N(N-1)}$$ (Simpson, 1949);

Shannon-Weaver diversity index:

$$H' = \sum_{i=1}^{S} \frac{ni}{N} \times \ln \frac{ni}{N}$$ (Shannon-Weaver, 1963),

where *ni* = number of specimens in the *i*th species and *N* = total number of specimens in each sample.

An expression of "evenness", J' = H'/H'max (Pielou, 1966) was also computed.

- *Statistics*

Statistics included mean and standard deviation (S.D.) as well as the Kruskal-Wallis one-way analysis of variance and the Mann-Whitney U test (Siegel, 1956) to assess the differences between the parameters and the indices of the samples in each site.

- *Cluster analysis*

Dendrograms were produced by hierarchical agglomerative clustering using the unweighted paired-group method of averaging (UPGMA). Cluster analysis was computed on the mean monthly values of the number of specimens of the taxa collected and identified at the species level.

Dendrograms were based on the Bray-Curtis dissimilarity (*D*) measures calculated on log-transformed (ln x+1) data, not considering the rare species.

The Bray-Curtis dissimilarity (*D*) between two samples was calculated from the following equation:

$$D_{jk} = \frac{\sum_{i=1}^{S} \left| y_{ij} - y_{ik} \right|}{\sum_{i=1}^{S} \left(yij + yik \right)},$$

where *yij* is the abundance of the species *i* in sample *j* and *yik* the abundance of species *i* in the sample *k*.

# # # # # # #

3 - RESULTS

3.1 - SMALL SCALE FISHERIES AND THE UTILISATION OF THE SKID TRAWL NET

Tables 2 and 3 summarise the data concerning the interviews made to fishermen in the provinces of Trapani and Palermo. As many as 43 skid trawls were censused in the province of Palermo. In seven of the nineteen localities fishermen used to employ the skid trawl. Doubts persist concerning four fisheries in which it has been impossible to obtain any reliable information, since fishermen kept the gear hidden because of its illegality. In the province of Trapani the skid trawl was used in five localities out of eighteen; the number of skid trawls censused was 37. Two fisheries provided unreliable data, and the level of suspicion encountered was much higher than in the province of Palermo. For this reason the census data could be underestimated.

The main characteristic of the gears and of the methods of fishing do not differ very much between the two provinces. The lightest skid trawls, weighing 7-10 kg and with an average mesh size of about 7mm, are generally used to catch prawns. The largest gears, weighing up to 40-50 kg and with average mesh size of about 13mm, are used instead to catch both prawns and sea urchins.

Small-sized prawns caught with the little skid trawls are usually sold to amateur fishermen who use them in summertime as living bait for hook-and-line fishing. In this instance, sea urchins may be considered as a by-catch and are either consumed by the fishermen's families or, less frequently, sold on the docks. The largest skid trawl are able to catch also large-sized prawns used as living bait for longline by the fishermen themselves. The large number of sea urchins caught in this instance are sold in different ways: sometimes they are booked in advance by private buyers, sometimes sold to wholesalers or less frequently sold directly on the docks.

As a general rule, skid trawl fishing is practised where dense and wide seagrass meadows are present on the shallow coastal bottoms.

3.2 - DENSITY OF SHOOTS

The average number of shoots per m² is shown in Table 4. The seagrass density was significantly higher ($P<0.001$) at Capo Feto (787 shoots/m²) than at Tonnarella (487.5 shoots/m²). The maximum was attained in station 1 at Capo Feto (875 shoots/m²), the minimum in station 1 at Tonnarella (412 shoots/m²).

3.3 - PHAENOLOGICAL PARAMETERS

3.3.1 - Number of leaves

The monthly average number of leaves per shoot and per square meter, calculated for the three age classes, is shown in Tables 5-6 and Figure 8.

The average number of total leaves per shoot ranged from 7 in November to 3.9 in July at Tonnarella, and from 6.7 in November to 4 in September at Capo Feto (Tab. 5). No statistically significant difference was evident comparing the total number of leaves in the two sites on a yearly scale (Tab. 7). The comparison between the seasonal values in the two sites showed a significant difference only in winter ($P<0.05$). Comparing the four seasonal values within each site, a significant difference was found in both of them. Taking into account the three age classes, no significant difference was evident between the two sites, with the exception of the adult leaves number, significantly higher at Tonnarella ($P<0.01$), and in few cases in the seasonal comparison between the two sites (Tab. 7). Comparing the four seasonal values within each site, the number differed significantly for intermediate and juvenile leaves, but not for the adult ones.

The number of leaves per square meter, which takes into account the shoot density, was generally much higher at Capo Feto (Tab. 6, Fig. 8). The number of total leaves ranged from 3425 in November to 1893 in July at Tonnarella, and from 5234 in November to 3161 in September at Capo Feto. This was due to the higher shoot density at Capo Feto, which affects the average number of leaves per square meter. The differences were highly significant both between the global values in the two sites and among the seasonal values within each site, with only a few exceptions. Comparing the seasonal values between the two sites, the difference was generally significant with the exception of adult leaves in winter and of juveniles in autumn, winter and spring.

3.3.2 - Leaf area index

The average leaf area index (LAI), calculated for the three age classes, is shown in Table 8 and Figure 9.

The total LAI ranged from 18.35/m² in July 1995 to 8.64/m² in November at Tonnarella, and from 24.24/m² in July 1995 to 8.59/m² in November at Capo Feto. There was no significant difference in the annual comparison of the values between the two sites, except for the overall leaves (Tab. 9), and slight differences were found comparing the seasonal values between the two sites. A strong seasonal variability of LAI characterised both sites, with generally highly significant differences.

3.3.3 - Leaf surface

The average leaf surface per shoot (LS), calculated for the three age classes, is shown in Table 10 and Figure 9.

The LS values of the overall leaves per shoot ranged from 376 in July to 177 in November at Tonnarella, and from 308 in July to 109 in November at Capo Feto. The values were significantly higher at Tonnarella than at Capo Feto for the adult ($P<0.05$) and the overall ($P<0.01$) leaves, while no significant differences were found in the intermediate and juvenile leaves (Tab. 11). In the seasonal comparison between the two sites only the overall leaves showed significant differences ($P<0.05$) in summer and autumn.

The seasonal variation of LS within each site were always very strong and statistically significant (Tab. 11).

3.3.4 - Coefficient *a*

The values of the coefficient *a* calculated in the two sites are shown in Table 12 and Figure 10.

In both sites the highest percentage of broken leaves was reached in September and the lowest in February by adult leaves. No significant difference was found by comparing the values of *a* between the two sites, except for intermediate leaves ($P<0.05$) with a higher value at Tonnarella (Tab. 13). The seasonal comparison between the two sites showed a significant difference only in winter for intermediate leaves. Few significant differences were also shown by the seasonal comparison within each site, namely for intermediate leaves in both sites ($P<0.05$) and for global leaves at Capo Feto ($P<0.05$).

3.3.5 - Length at the base of adult leaves

The average length at the base of adult leaves ranged between 4 and 6 cm in both sites (Fig. 11). No significant difference was found comparing the values of the two sites and the seasonal values within each site (Tab. 14). The autumn value was significantly higher at Tonnarella ($P<0.05$).

3.4 - PHYSICAL EFFECTS OF SKID TRAWLING ON THE SEAGRASS MEADOW

The visual observations carried out by SCUBA divers along the 200 meters transect in the two sites are resumed in Photos 7-8. The skid trawl passage was observed from different positions whilst the codend was getting filled. No evidence of a physical impact of the gear on the seagrass was recorded after the skid trawl passage in any period and site. Neither broken shoots or leaves were observed, nor any clear damage was detectable on the plants in the different spatial strata: leaves, rhizomes, *matte*. Furthermore no statistical difference was evident comparing the average shoot density in the trawled area with that of the control area in both sites and sampling periods.

3.5 - COMPOSITION OF THE VAGILE FAUNA OF LEAF STRATUM COLLECTED BY HAND-TOWED NET

3.5.1 - Tonnarella

Table 17a displays the monthly mean number of specimens collected at Tonnarella, the total abundance of every taxon in the whole study period (No.) and its percent contribution to the total (%No.), also depicted in Fig. 13. Only decapod crustaceans and molluscs were identified at the species level (Annex 1; see chapters 3.5.1.1. and 3.5.1.2).

A total of 18321 specimens was collected. Amphipods were the most abundant group (No.=9137), accounting for almost 50% of the total, followed by gastropods (16.1%), isopods (13.3%), decapods (8.8%), copepods (7.3%) and ostracods (2.9%). The contribution of each of the remaining groups was <1%. The variability of abundance from one month to the next was not high, and in any case much lower than at Capo Feto. The highest mean number of specimens was collected in July 1995 (=1633), the lowest in November 1994 (=437.5). Figure 12 displays the monthly trend of the mean abundance of the overall benthic fauna.

3.5.1.1 - *Decapod crustaceans*

Table 15 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 1617 decapods (1529 belonging to 18 species plus 88 unidentified) were collected. The species included 10 shrimps, 4 hermit crabs, 2 galatheid crabs and 2 brachyuran crabs. The most represented family was Hippolytidae (5 species). The hermit crab *Cestopagurus timidus* was the most abundant and most frequent decapod (No.=948, %No.=58.6, %F=91). It was followed by the shrimps *Athanas nitescens* (No.=186, %No.=11.5, %F=65), *Hippolyte inermis* (No.=135, %No.=8.3, %F=82) and *Hippolyte* spp. (No.=77, %No.=4.8, %F=82), the hermit crab *Pagurus chevreuxi* (No.=64, %No.=4.0, %F=56), the shrimps *Thoralus cranchii* (No.=49, %No.=3.0,

%F=65) and *Hippolyte longirostris* (No.=44, %No.=2.7, %F=60). The remaining species occurred in less than 50% of the samples.

Fig. 14 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.5.1.2 - Molluscs

Table 15 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2957 molluscs (2785 belonging to 28 species plus 172 unidentified) were collected. The species were all prosobranch gastropods. The most represented family was Rissoidae. The most abundant species was *Rissoa auriscalpium* (No.=904, %No.=30.6, %F=91), whereas the most frequent were *Gibbula umbilicaris* (No.=159, %No.=5.4, %F=95) and *Tricolia pullus* (No.=381, %No=12.9, %F=95), followed by *Jujubinus exasperatus* (No.=202, %No.=6.8, %F=87), *Tricolia speciosa* (No.=152, %No.=5.1, %F.=82), *Rissoa variabilis* (No.=148, %No.=5.0, %F=82), *Pusillina* spp. (No.=160, %No.=5.4, %F=73), *Rissoa violacea* (No.=121, %No.=4.1, %F=65), *Bittium reticulatum* (No.=305, %No.=10.3, %F=60), *Clanculus cruciatus* (No.=86, %No.=2.9, %F=60), *Mitrella scripta* (No.=119, %No.=4.0, %F=56), *Jujubinus striatus* (No.=26, %No.=0.9, %F=52). The remaining species occurred in less than 50% of the samples.

Fig. 15 shows the relative importance of the most abundant and most frequent mollusc species in the two sampling sites.

3.5.2 - Capo Feto

Table 17b displays the monthly mean number of specimens collected at Capo Feto, the total abundance of every taxon in the whole study period (No.) and its percent contribution to the total (%No.), also depicted in Fig. 13. Only decapod crustaceans and molluscs were identified at the species level (Annex 1; see chapters 3.5.2.1 and 3.5.2.2).

A total of 26252 specimens was collected. Amphipods were the most abundant group (No.=18174), accounting for over 69% of the total, followed by gastropods (8.1%), isopods (6.2%), decapods (5.3%), copepods (4.8%) and ostracods (3.4%). The contribution of each of the remaining groups was ≤ 1%. A high variability of the abundance was generally found from one month to the next. The highest mean number of specimens was collected in September 1994 (=2542), October 1994 (=2495.5) and July 1995 (=2435); the lowest in March 1995 (=80). Fig. 12 shows the monthly trend of the mean abundance of the overall benthic fauna.

3.5.2.1 - *Decapod crustaceans*

Table 16 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 1400 decapods (1226 belonging to 21 species plus 174 unidentified) were collected. The species included 9 shrimps, 4 hermit crabs, 2 galatheid crabs and 6 brachyuran crabs. The most represented family was Hippolytidae (the same 5 species as Tonnarella). The hermit crab *Cestopagurus timidus* was the most abundant and most frequent decapod (No.=415, %No.=29.6, %F=100). It was followed by the shrimps *Hippolyte inermis* (No.=368, %No.=26.3, %F=95), *Athanas nitescens* (No.=168, %No.=12.0, %F=70), *Hippolyte* spp. (No.=162, %No.=11.6, %F=83), *Hippolyte longirostris* (No.=113, %No.=8.1, %F=79) and *Thoralus cranchii* (No.=49, %No.=3.5, %F=58). The remaining species occurred in less than 50% of the samples.

Fig. 14 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.5.2.2 - *Molluscs*

Table 16 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2124 molluscs (1924 belonging to 35 species plus 200 unidentified) were collected. The species included 33 prosobranch gastropods and 2 opistobranch gastropod. The most represented family was Rissoidae. The most abundant species was the prosobranch *Rissoa auriscalpium* (No.=583, %No.=27.4, %F=91), whereas the most frequent was *Gibbula umbilicaris* (No.=108, %No.=5.1, F%=100). The other most frequent species were *Tricolia pullus* (No.=188, %No.=8.8, %F=91), *Tricolia speciosa* (No.=176, %No.=8.29, %F=87), *Rissoa variabilis* (No.=154, %No.=7.2, %F=66), *Pusillina* spp. (No.=141, %No.=6.6, %F=75), *Rissoa violacea* (No.=87, %No.=4.1, %F=70), *Mitrella scripta* (No.=77, %No.=3.6, %F=62), *Jujubinus exasperatus* (No.=69, %No.=3.2, %F=91), *Columbella rusitca* (No.=64, %No.=3.0, %F=70) and *Calliostoma laugeri* (No.=27, %No=1.3, %F=62). The remaining species occurred in less than 50% of the samples.

Fig. 15 shows the relative importance of the most abundant and most frequent mollusc species in the two sampling sites.

3.6 - COMMUNITY STRUCTURE

Table 18 shows the mean values of the community structure indices, expressed graphically in Figure 16. All the indices were calculated on a seasonal basis, using the abundance data of molluscs and decapod crustaceans.

3.6.1 - Tonnarella

The values of the community structure indices are shown in table 18. The number of specimens collected was higher in summer (No.=342.0), followed by spring; this value was much lower in autumn (No.=100.8) and winter (No.=63.3). The species richness was higher in spring (S=21.1, d'=3.8), followed by summer, autumn and winter. The highest diversity was recorded in spring (H'=2.3), followed with slightly lower values by autumn, summer and winter. The evenness displayed the same value in autumn, winter and spring (J'=0.8), followed by summer. The dominance had the same value (λ'=2) in all the seasons.

3.6.2 - Capo Feto

The number of specimens collected was higher in spring (No.=172.9), followed by autumn and summer; the winter value was much lower than any other (No.=43.5). The species richness was higher in summer (S=23.5, d'=4.7), followed by spring, autumn and winter. The highest diversity was recorded in summer (H'=2.6), followed by spring and autumn (with the same value, H'=2.2) and by winter. The evenness displayed the same value in summer, autumn and winter (J'=0.8), followed by spring (J'=0.7). The dominance had the same value (λ'=0.2) in autumn, winter and spring, followed by summer (λ'=0.1).

3.7 - COMPARISONS

Table 19 shows the results of the statistical tests performed on the no. of specimens and on the community structure indices calculated for each replicate.

No difference between the two sites was found comparing the annual data. Comparing the seasonal data within each site, a significant difference was found for No. and S in both sites, and for d' and H' at Capo Feto only. Comparing the two sites in each season, a significant difference ($P<0.05$) was found only for d' in summer.

The cluster analysis (Fig. 17) did not show any group between the two stations; only a slight seasonal variation was found within each site.

3.8 - SKID TRAWL FISHING

3.8.1 - Catch composition

Twelve skid trawl tows were made every month from June 1994 to July 1995 in each site. The swept area ranged from 469 m² to 863 m² at Capo Feto and from 511 m² to 735 m² at Tonnarella; the irregular speed of the boat accounts for the variability of the swept areas (Tab. 20). Fig. 26 shows the percent contribution of each taxon to the total catch in the two sites, on a yearly basis. The average weight (kg) of the main items caught in each haul is shown in Table 21, while the standardised weight (kg/ha) is given in Table 22. Generally both the average and the standardised weights were higher at Tonnarella than at Capo Feto for all the taxa, with the exception of crustaceans and of the least abundant groups ("others"), in the whole sampling period (Fig. 18). The dead and living *P. oceanica* leaves and *matte* made up the bulk of each haul in the two sites (Fig. 19). These items accounted for about 60% (living *matte* 22%, dead *matte* 20%, living leaves 5% and dead leaves 13%) of the total catch at Tonnarella and for about 75% (living *matte* 33%, dead *matte* 10%, living leaves 11% and dead leaves 21%) at Capo Feto.

Taking into account only the vegetal portion of the global standardised catch (Fig. 20a, b), living *matte* (39%) and dead leaves were the most abundant items at Capo Feto, followed by living leaves (14%), dead *matte* (12%) and algae (10%); living (31%) and dead (26%) *matte* were the most abundant items at Tonnarella, followed by algae (19%), dead leaves (17%) and living leaves (7%). The most abundant algae collected were *Cystoseira* spp., *Ectocarpus* spp., *Halopteris scoparia*, *Padina pavonia*, *Codium bursa*, *Udotea petiolata*, *Polysiphonia* spp.

As far as the animal component is concerned (Fig. 20c, d), echinoderms dominated the standardised catch in both sites (50% at Capo Feto and 82% at Tonnarella), followed by crustaceans (24%), fish (20%), molluscs (5%) and other groups (1%) at Capo Feto and by fish (8%), crustaceans (6%), molluscs (4%) and other groups (less than 0.1%) at Tonnarella.

- <u>*Posidonia oceanica* leaves</u>.

The dead *P. oceanica* leaves (brown portion) reached the maximum value in the hauls of November '94 in both sites, when they accounted for more than 30% of the total leaves collected and more than 65% of the total catch (Tabb. 21-22; Figg. 21-22). The minimum was instead reached in April '95 when the dead leaves were less than 1% of the total catch in both sites, and about 9% of the total leaves collected at Capo Feto and 19% of those collected at Tonnarella.

The amount of dead leaves ranged from 11.5 kg (169 kg/ha) to 0.04 kg (0.61 kg/ha) at Capo Feto, and from 15.6kg (237.7 kg/ha) to 0.09 kg (1.37 kg/ha) at Tonnarella (Figg. 21-22 and Tabb. 21-22).

The living *P. oceanica* leaves (green portion) reached the maximum in July '94 in both sites, when they were about 70% of the total leaves collected and more than 50% of the total catch (Tabb. 21-22; Figg. 19-20) in both site. The minimum was instead reached in January '95 at Capo Feto, when the living leaves were about 1% of the total catch and about 26% of the total leaves collected, and in April '95 at Tonnarella, where the living leaves were less than 1% of the total catch but more than 80% of the total leaves collected.

The amount of living leaves ranged from 2.8 kg (45.16 kg/ha) to 0.3 kg (3.88 kg/ha) at Capo Feto, and from 2.4 kg (38.9 kg/ha) to 0.4 kg (5.82 kg/ha) at Tonnarella.

The annual trend of the average yield of both living and dead leaves was similar in the two sites (Figg. 21-22). The yields of living leaves generally overcame those of dead leaves, with the exception of the period between late summer and January. Statistical comparisons (Tab. 23) did not reveal any significant difference between the two sites, both in the yearly scale and in the seasonal scale. A significant seasonal variation within each site occurred instead for both living ($P<0.05\%$) and dead ($P<0.01\%$) leaves.

- *Posidonia oceanica matte*

As far as the *P. oceanica matte* is concerned, it was not collected regularly during the year. Generally hauls contained both living and dead *matte*, but sometimes only one of them was present. The maximum yield of *matte* at Capo Feto was obtained in January '95 with 12 kg (155.3 kg/ha, living *matte*), i.e. about 60% of the total catch and about 82% of the whole *matte*. The minimum (not including 0 values) was obtained by the dead *matte* in September '94 with 0.36 kg (5.9 kg/ha). This value was about 3% of the total catch and about 15% of the whole *matte* collected (Tabb. 21-22).

In Tonnarella the maximum yield of *matte* was attained in April '95 by the dead *matte* with 15.1 kg (225.9 kg/ha), which was about 65% of the whole *matte* collected and about 37% of the total catch. The minimum value was reached in June '95 by the dead *matte* with 1.14 kg (15.8 kg/ha), corresponding at about 10% of the total catch and about 20% of the whole *matte* collected (Tabb. 21-22).

No statistical differences resulted from the seasonal comparison between the two sites (Tab. 23), while on the annual basis the dead *matte* was collected in significantly larger amounts at Tonnarella ($P<0.05$). Seasonal significant differences within each site were instead found for both the living ($P<0.01$) and the dead ($P<0.05$) *matte*.

- *Algae*

Algae were a constant item at Tonnarella (Tabb. 21-22); their yields ranged from 0.01 kg (0.24 kg/ha) in September to 13.97 kg (228 kg/ha) in May. The largest catches were generally characterised by some large specimens of *Codium*.

Algae were not collected at Capo Feto only in two occasions (including replicates): July '94 and July '95. In the other months the average weight ranged from 0.05 kg in June '94 (1.1 kg/ha) to 2.91 kg in April '95 (39 kg/ha). There was a significant difference between the two sites ($P<0.05$) in the annual comparison, and only in spring in the seasonal comparison ($P<0.01$) (Tab. 23). The seasonal variation within each site was significant only at Tonnarella ($P<0.05\%$).

- *Animal component*

As for the animal component, molluscs, crustaceans, echinoderms and fish were the most common and/or abundant items (Tabb- 21-22; Figg. 23-24).

Crustaceans were made up mainly of decapods. The average yields ranged from 0.13 kg (2.40 kg/ha) in September '94 to 0.66 kg (8.88 kg/ha) in April '95 at Capo Feto, and from 0.09 kg (1.59 kg/ha) in November '94 to 0.59 kg (8.99 kg/ha) in June '94 at Tonnarella (Tabb. 21-22; Figg. 23-24). No significant difference was found comparing the annual average values of the two sites, while a significant difference ($P<0.05$) was detected in winter. A significant seasonal variation ($P<0.01\%$) was also found at Tonnarella (Tab.23).

Molluscs were constantly present every month (Tabb. 21-22; Figg. 23-24). They reached a minimum of 0.01 kg (0.17 kg/ha) in July '94 and a maximum of 0.17 kg (2.79 kg/ha) in November '94 at Capo Feto, while at Tonnarella the lowest value was attained in April '95 (0.05 kg, 0.78 kg/ha) and the highest in June '95 (0.64 kg, 9.68 kg/ha). The statistical comparisons are given in Table 23. A significant difference ($P<0.01$) was found comparing the global values of the two sites. The seasonal comparison within each site showed a significant difference ($P<0.05$) only at Tonnarella. The seasonal comparison between the two sites showed significant differences only in summer ($P<0.05$) and spring ($P<0.01$).

Echinoderms, mainly sea urchins, yielded from 0.05 kg (0.77 kg/ha) in June '94 to 1.92 kg (28.9 kg/ha) in November '94 at Capo Feto, and from 0.05 kg (0.74 kg/ha) in September '94 to 10.17 kg (162.7 kg/ha) in April '95 at Tonnarella (Tabb. 21-22; Figg. 23-24). The average yield was significantly higher at Tonnarella ($P<0.01$) than at Capo Feto on a yearly basis (Tab. 23). This difference was very strong in spring ($P<0.001$), as evidenced by the seasonal comparison between the two sites. No significant variation was detected on a seasonal scale within each site (Tab. 23).

Fish catch ranged from 0.05 kg (0.98 kg/ha) in June '94 to 0.55 kg (8.23 kg/ha) in November '94 at Capo Feto, and from 0.14 kg (2.40 kg/ha) in July '94 to 0.65 kg (9.92 kg/ha) in June '94 at Tonnarella (Tabb. 21-22; Figg. 23-24). Significant differences ($P<0.01$) were detected comparing the two sites on an annual basis as well as in spring. The seasonal variation within each site was significant ($P<0.01$) only at Capo Feto (Tab. 23).

3.9 - SPECIES COMPOSITION OF THE SAMPLES

3.9.1 - Tonnarella

3.9.1.1 - *Decapod crustaceans*

Table 24 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 1897 decapods (1763 belonging to 41 species plus 134 unidentified) were collected. The species included 13 shrimps, 1 ghost shrimp, 1 lobster, 7 hermit crabs, 3 galatheid crabs and 16 brachyuran crabs. The most represented family was Majidae (9 species). The most abundant species was the shrimp *Palaemon xiphias* (No.=631, %No.=33.3, %F=100), followed by *Processa edulis* (No.=235, %No.=12.4, %F=92) and *Pisa muscosa* (No.=173, %No.=9.1, %F=75); 7 other species occurred in more than 50% of samples.

Fig. 27 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.9.1.2 - *Molluscs*

Table 24 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2920 molluscs (33 polyplacophors, 2667 gastropods, 205 bivalves and 15 cephalopods) were collected. The dominant group was gastropods (91.3% of the total), which included 42 species. The most abundant species was *Gibbula umbilicaris* (No.=391, %No.=14.7, %F=100), followed by *Petalifera petalifera* (No.=334, %No.=12.5, %F=62), *Rissoa auriscalpium* (No.=275, %No.=10.3, %F=66) and *Rissoa violacea* (No.=230, %No.=8.6, %F=58); 8 other species occurred in more than 50% of samples.

Fig. 28 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.9.1.3 - *Echinoderms*

Table 24 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2245 echinoderms (2239 belonging to 7 species plus 6 unidentified) were collected. The most frequent and abundant were *Paracentrotus lividus* (No.=1340, %No.=59.7, %F=88), *Psammechinus microtubercularis* (No.=796, %No.=35.5, %F=79) and *Sphaerechinus granularis* (No.=41, %No.=1.8, %F=58).

Fig. 29 shows the relative importance of these three species in the two sampling sites.

3.9.1.4 - *Fishes*

Table 24 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 409 fish (347 belonging to 23 species plus 62 unidentified) were collected. The most represented family was Labridae (8 species). The most abundant was *Scorpaena porcus* (No.=104, %No.=25.4, %F=88), followed by *Chromis chromis* (No.=72, %No.=17.6, %F=83). *Symphodus rostratus* and unidentified Gobiidae occurred in more than 50% of samples.

Fig. 30 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.9.2 - Capo Feto

3.9.2.1 - *Decapod crustaceans*

Table 26 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2621 decapods (2489 belonging to 41 species plus 132 unidentified) were collected. The identified species included 14 shrimps, 1 lobster, 5 hermit crabs, 3 galatheid crabs, 1 porcellanid crab and 17 brachyuran crabs. The most represented family was Majidae (8 species). The most abundant species was the shrimp *Palaemon xiphias* (No.=1121, %No.=42.8, %F=96), followed by *Processa edulis* (No.=262, %No.=10.0, %F=83); 14 other species occurred in more than 50% of samples.

Fig. 27 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.9.2.2 - *Molluscs*

Table 26 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 2002 molluscs (39 polyplacophors, 1768 gastropods, 186 bivalves and 9 cephalopods) were collected. The dominant group was gastropods (88.3% of the total molluscs), which included 44 species. The most abundant species was *Gibbula umbilicaris* (No.=240, %No.=13.7, %F=96)., followed by *Rissoa auriscalpium* (No.=183, %No.=10.4, %F=67) and *Tricolia speciosa* (No.=178, %No.=10.1, %F=87); 6 other species occurred in more than 50% of samples.

Fig. 28 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.9.2.3 - *Echinoderms*

Table 26 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 305 echinoderms (301 belonging to 7 species plus 4 unidentified) were collected. The most frequent and abundant were *Paracentrotus lividus* (No.=215, %No.=70.5, %F=79), *Psammechinus microtubercularis* (No.=56, %No.=18.4, %F=46), *Sphaerechinus granularis* (No.=2, %No.=0.7, %F=4).

Fig. 29 shows the relative importance of these three species in the two sampling sites.

3.9.2.4 - *Fishes*

Table 26 displays the data in terms of mean no. of specimens per month, frequency of occurrence in the samples (%F), total no. in the whole study period (No.) and percentage in number (%No.).

A total of 321 fish (234 belonging to 21 species plus 87 unidentified) were collected. The most represented family was Labridae (9 species). The most abundant were unidentified Gobiidae (No.=85, %No.=26.5, %F=71), followed by *Scorpaena porcus* (No.=72, %No.=22.4, %F=75). Three other species occurred in more than 50% of samples.

Fig. 30 shows the relative importance of the most abundant and most frequent decapod species in the two sampling sites.

3.10 - COMMUNITY STRUCTURE

Table 27 shows the mean values of the community structure indices, expressed graphically in Figure 31. All the indices were calculated on a seasonal basis, using the abundance data of the taxa identified at the species level (decapod crustaceans, molluscs, echinoderms and fish).

3.10.1 - Tonnarella

The number of specimens collected was higher in spring (No.=383.50), followed by winter, autumn and summer. The same trend was displayed by the species richness, with its maximum in spring (S=45.40, d'=7.56), followed by winter, autumn and summer. The highest diversity was recorded in autumn (H'=2.99), followed by winter, spring and summer. The evenness displayed the highest value in autumn (J'=0.82), followed by summer, winter and spring. The dominance was higher in summer (λ '=0.16), followed by spring, winter and autumn.

3.10.2 - Capo Feto

The number of specimens collected was higher in autumn (No.=332.50), followed by winter and spring; the summer value was much lower than any other (No.=87.00). The species richness was higher in autumn (S=45.83, d'=7.76), followed by winter, spring and summer. Autumn again displayed the highest diversity (H'=2.99), followed by winter, spring and summer. The highest evenness was recorded in spring and summer (J'=0.80), the lowest in winter (J'=0.77). The dominance index displayed its maximum in summer (λ'=0.15), followed by winter and spring; the minimum was reached in autumn (λ'=0.09).

3.11 - COMPARISONS

There was no statistically significant difference in the number of specimens globally collected in the two sites.

Table 28 shows the results of the statistical tests performed on the no. of specimens and on the community structure indices calculated for each replicate.

No difference between the two sites was found comparing the annual data. Comparing the seasonal data in each site, a significant difference ($P<0.05$) was found only for No. and S in Capo Feto. Comparing the two sites in each season, a significant difference was found only for d' in autumn ($P<0.05$) and for S in spring ($P<0.01$).

The cluster analysis (Fig. 32) did not show any group between the two stations; only a slight seasonal variation was found within each site.

4 - DISCUSSION

The impact of the skid trawl is evident on the whole *P. oceanica* system, including every portion of the plant (leaves and rhizome) and all the sessile and vagile organisms associated (Ardizzone & Pelusi, 1984).

Starting from our data, the damage to the system can be put into evidence in different ways. First of all by analysing the catch composition of the experimental tows made in the two sampling sites; secondly by comparing the results coming from the study site with those of the control site; in the third place by comparing the amount of the plant and of the vagile fauna of leaf stratum *in situ* with the amount collected with the experimental tows.

4.1 - THE SKID TRAWL IMPACT ON A SHALLOW *POSIDONIA OCEANICA* SYSTEM

The evaluation of the skid trawl impact on the *P. oceanica* system presents many difficulties, due to the extreme complexity of the system itself. This includes the plant with leaves and rhizomes, as well as the so-called *matte* made up of a complex of dead and/or live rhizomes, sediment and organic debris. Sampling on the meadow may lead to collect (even simultaneously) live and dead portions of the plant, depending to a great extent on the season and on the hydrodynamism of the site (Romero *et al.,* 1992). The *P. oceanica* system also includes two groups of associated organisms: those living in the leaf stratum and those living in the rhizome stratum (Templado, 1984). Moreover we have a sessile and a vagile fauna.

A rough estimate of the direct effect of fishing may be drawn from the analysis of the composition of the experimental hauls (Tabb. 21-22). As it may be seen, the bulk of the catch consists of plant portions.

To precisely assess the impact of the net on every part of the system a comparison of the trawling data with the components of the system *in situ* (*i.e.* number of leaves and rhizomes, amount of *matte*, fauna and flora standing crop) is needed.

The amount of live leaves collected can be compared with the amount of live leaves in the meadow (chapter 4.2), but the comparison with dead leaves or with the *matte* is much more difficult.

As for the fauna a reliable evaluation of the effect of trawling may be based on the vagile leaf stratum assemblage (chapter 4.3). The hand-towed net method is in fact assumed to sample **all** the vagile fauna of leaf stratum, so making it possible to estimate the real density of this component. Such evaluation is much more difficult to be made on the rhizome stratum assemblage or on the fish fauna: any estimate of the standing crop of the latter assemblages is in fact hard because their sampling is difficult and time consuming.

The comparison between study site and control site in order to get an indirect estimate of the skid trawl impact on the *P. oceanica* system, did not lead to clear and unmistakable conclusions. The most striking difference between the two sites concerned the average shoot density, which was significantly higher at Capo Feto. Any other difference, including the phaenological parameters (not taking into account those connected with the shoot density), the quali-quantitative composition and the structure of the vagile fauna of leaf stratum, showed that the variation within each site is generally greater than the variation between sites. Moreover a greater number of echinoderms, including edible sea urchins, was caught in the study site.

4.2 - IMPACT ON THE PLANT

As said above the impact on the plant, besides from the trawling data and from the visual observation, can be assessed by comparing the leaves standing crop with the amount of leaves collected per unit area by the skid trawl. In table 29 the average dry weight of leaves per shoot in each sampling date is shown. This datum follows the same monthly trend of the average number of leaves per shoot and of the LAI index. In the same table the average rhizomes dry weight values are shown. This last datum however has to be considered as purely indicative in this framework, due to the great variability of the dimension and weight of rhizomes.

Starting from the data in table 29, the monthly standing crop (wet weight) was extrapolated for leaves, rhizomes and shoots (=leaves plus rhizomes) using 1) a linear regression between the wet and the dry weight values and 2) the density data previously calculated in the two sampling sites. This allowed us to compare the amount of live leaves and rhizomes monthly caught by the skid trawl with the amount of *in situ* leaves, rhizomes and shoots. Since in the catch data of tables 21-22 rhizomes (when collected) and living leaves were pooled together in the item "living leaves", comparisons present some difficulties.

If we compare the amount of leaving leaves (leaves plus rhizomes) caught every month by the skid trawl with the standing crop (in the same unit surface) of leaves, rhizomes and shoots we can roughly assess the impact of skid trawling on the different portions of the plant. Table 31 shows the percentage of living leaves caught on average by the skid trawl in the two sampling sites in comparison with the corresponding standing crop. The average impact on leaves ranged from 0.1% to 0.02% at Tonnarella and from 0.08% to 0.01% at Capo Feto. Lesser values not exceeding 0.05 percent were achieved by the impact on rhizomes and shoots. On the whole the average percentage of impact was lower at Capo Feto than at Tonnarella.

From table 31 it results that all the live *P. oceanica* collected by the skid trawl in a given area was generally less than 0.1% of the leaves standing crop and less than 0.04% of the shoots standing crop.

4.3 - IMPACT ON THE ASSOCIATED ORGANISMS

At least two different communities characterise the *P. oceanica* system: the leaf assemblage and the rhizome/*matte* assemblage. The skid trawl proved to be a reliable sampler of both.

Since the hand-towed net collects selectively the vagile fauna of leaf stratum (Gambi *et al.*, 1992), taking as a reference the faunistic list of the hand-towed net (tables 15-16) it has been possible to distinguish the molluscs and decapods of leaf stratum and of rhizome/matte stratum in the skid trawl samples. In doing this we did not take into account the rare species (*i.e.* those occurring less than twice in the whole hand-towed net sampling).

Following this criterion, only 12 decapod species out of 32 and 21 mollusc species out of 47, collected by the skid trawl at Tonnarella may be ascribed to the vagile fauna of leaf stratum (Tab. 32), but the number of specimens of leaf stratum is about twice as much as that of rhizome stratum. Similar results as for the number of specimens were obtained at Capo Feto, where only 11 decapod species out of 29 and 19 mollusc species out of 47 may be ascribed to the leaf stratum.

The efficiency of the skid trawl as a sampler of the leaf stratum fauna is highlighted by the fact that only 2 species at Capo Feto and 4 at Tonnarella (excluding the rare taxa) were collected exclusively by the hand-towed net.

The percentage in number of species and of specimens of decapods and molluscs belonging to the different strata of the *P. oceanica* system is shown in figure 37. Even if the number of species belonging to the rhizome/matte stratum is higher than that of the leaf stratum, the skid trawl efficiency seems higher in harvesting the vagile fauna of leaf stratum. Of course the specimens density in the two strata are not comparable.

The impact on the leaf stratum vagile fauna was assessed taking as a reference the mollusc and decapod taxocoenoses. As said in chapter 4.1, the hand-towed net is supposed to collect all the vagile fauna of leaf stratum. Since we know the surface sampled by the hand-towed net (chapter 2.2.2), we are able to estimate the density of each leaf stratum species. If we standardise to the same unit area the hand-towed net and the skid trawl data, we can evaluate the proportion of specimens of leaf stratum collected by the skid trawl in comparison to their real density (estimated with the hand-towed net sampling). Figures 33 to 36 depict these proportions.

Figures 33 and 34 show the data of Tonnarella concerning the overall study period. Figure 34 does not include *Palaemon xiphias* and *Processa edulis* because, though frequently occurring in the hand-towed net samples, they were collected in extremely higher amounts with the skid trawl, contrary to any other leaf stratum species. Only *Vitreolina curva*, *Fusinus pulchelllus*, *Gibbula ardens*, *Gibbula umbilicaris* and *Rissoa violacea* among molluscs and *Pagurus anachoretus* and *Eualus occultus* among decapods attained a value greater than 5%. All other species had values generally lesser than 1%. About 37% of *V. curva* caught by the hand-towed net was caught by skid trawl, but it should be kept in mind that this species parasitizes echinoderms.

Figures 35 and 36 show the data of Capo Feto. Only *Bittium reticulatum*, *Clanculus cruciatus*, *V. curva* and *G. umbilicaris* among molluscs and *P. anachoretus*, *Processa edulis*, *Macropodia longirostris* and *E. occultus* among decapods attained values greater than 5%. Contrary to Tonnarella, *P. edulis* was harvested in larger amounts per unit area with the hand-towed net. All other species had values generally lesser then 1%. About 35% of *B. reticulatum* and more than 50% of *P. anachoretus* and *P. edulis* caught by the hand-towed net were caught by trawling.

As regards the rhizome benthos, it is very difficult to extrapolate density and biomass values due to the dispersion of some large-sized species like echinoderms and to the burrowing and hiding habits of many small-sized species living in the crevices of the *matte*. Also the high motility of fish and of some prawns does not allow to make accurate evaluations. Moreover these estimates are time and money consuming. The leaf stratum vagile fauna instead can be easily collected by the hand-towed net method, which allows to make quantitative comparisons. The impact on the rhizome fauna and on the fish assemblage can only be qualitatively estimated from the catch data.

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5 - CONCLUSION

From this study the impact on the different portions of *P. oceanica* and on almost all the fauna associated to the different strata of the seagrass system can be clearly observed.

Where possible this impact was evaluated on single items and the percentage caught was, with a few exceptions, less than 1%. Although no catastrophic experimental catch was recorded, and no important difference was observed between the study site and the control site, the skid trawl cannot be considered a selective gear for the few large-sized species usually sought after by fishermen. It is able to catch all the fauna associated to *P. oceanica* as well as the plant itself. For this reason fishermen using this gear for the harvest of sea urchins and prawns cause a damage to the whole seagrass system. Due to the high ecological importance of this ecosystem in the Mediterranean Sea, a much greater attention should be paid by local administrators in order to stop this illegal fishing technique.

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6 - REFERENCES

Ardizzone, G.D., 1992: Cartografia bentonica con sistemi video controllarti a distanza. *Oebalia*, **XVII** (2): 441-152.

Ardizzone, G.D. & P. Pelusi, 1984: Yeld and damage evaluation of bottom trawling on *Posidonia* meadows. International workshop on *Posidonia oceanica* beds. Boudouresque , Ch.-F., de Grissac, A. J., Oliver J.: 63-72.

Bell, J.D. & Harmelin-Vivien M.L., 1982 - Fish fauna of french mediterranean *Posidonia oceanica* seagrass meadows. 1. Community structure. *Tethys* **10**(4): 337-347.

Bell, J.D. & M.L. Harmelin-Vivien, 1983: Fish fauna of French Mediterranean *Posidonia oceanica* seagrass meadows. 2 - Feeding habits. *Téthys*, **11**: 1-14.

Chessa, L. A., M. Scardi, E. Fresi & F. Russu, 1989: Consumers in *Posidonia* oceanica beds: 1. *Processa edulis* Risso Decapoda, Caridea. *GIS-Posidonia*: 243-249.

Chessa, L. A., M. Scardi, E. Fresi & S. Saba, 1989: Consumers in *Posidonia* oceanica beds: 2. *Galathea squamifera* Leach Decapoda, Anomura. *GIS-Posidonia*: 251-255.

Coulon, P., M. Jangoux & P. Bulteel, 1992: Respiratory rate and assessment of secondary production in the holoturoid *Holoturia tubulosa* (Echinodermata) from Mediterranean seagrass beds. P.S.Z.N. I.: *Marine Ecology*, **13**(1): 63-68.

Den Hartog, C., 1980: Foreword. In: R. C. Phillips & C. P. McRov (Eds.), Handbook of Seagrass Biology: an Ecosistem Perspective. *Garland STPM Press*,New York: ix-xiii.

Fresi, E., L.A. Chessa, M. Scardi, C. Impagliazzo, 1984: Feeding ecology of *Palaemon xiphias* Risso from a *Posidonia oceanica* meadownear Alghero (Sardinia). International workshop on *Posidonia oceanica* beds. Boudouresque , Ch.-F., de Grissac, A. J., Oliver J.: 331-334.

Gambi, M.C., M. Lorenti, G.F. Russo, M.B. Scipione, V. Zupo, 1992: Depth and seasonal distribution of some groups of the vagile fauna of the *Posidonia oceanica* leaf stratum: structural and trophic analyses. P.S.Z.N.1: *Marine Ecology*, **13** (1): 17-39.

Giraud, G., 1977: Contribution à la description et à la phènologie quantitative des herbiers de *Posidonia oceanica* (L.) Delile. Thèse en oceanologie , Aix-Marseillee **II**: 150 pp.

Harmelin-Vivien, M.L., 1981: Description d'un petit chalut à perche pour recoltèr la faune vagile des herbiers de Posidonies. *Rapp. Comm. int. Mer. Médit.*, **27**: 199-200.

Harmelin-Vivien, M.L., 1983: Etude comparative de l'ichtyofaune des herbiers de phanérogames marines en milieu tropical et tempéré. *Rev. Ecol*. (Terre Vie), Fr., **38**: 179-210.

ICRAM, 1989: Programma di studio per l'identificazione dei problemi e la formulazione di proposte rivolte a una correta gestione della fascia costiera della provincia di Trapani. Relazione per il Ministero della Marina Mercantile.

Lawrence, J. M., Ch.-F. Boudouresque & F. Maggione, 1989: Proximate constituent, biomass, and energyin Posidonia oceanica (Potamogetonaceae). P.S.Z.N. 1: *Marine Ecology*, **10** (3): 263-270.

Ledoyer, M., 1962: Etude de la faune vagile des herbiers superficiels de Zosteracées et de quelques biotopes d'algues littorales. *Recl Trav. Stn Mar. Endoume*, **39** (25): 117-235.

Matricardi, G., R. Muratori, M. Wurtz, 1992: Biological baseline for restocking projects on seagrass meadows. *Aquaculture* '92. Growing toward the 21th century. p. 157.

Mazzella, L. & G.F. Russo, 1989: Grazing effects of two *Gibbula* species (Mollusca, Archaeogastropoda) on the epiphytic community of *Posidonia oceanica* leaves. *Aquatic Botany*, **35**(3-4): 357-373.

Orru, P., 1990: Evidenze di degrado da pesca a strascico sulla piattaforma continentale del Golfo di Orosei (Sardegna orientale). Parchi marini del Mediterraneo aspetti naturalistici e gestionali. Cossu A., V. Gazales, I. Milella **I**. eds.: 247-255.

Ott, J. A., 1980: Growth and production in Posidonia oceanica (L.) Delile. P.S.Z.N.1: *Marine Ecology*, **1**: 47-64.

Pergent, C., V. Rico-Raimondino & G. Pergent, 1994: Primary production of *Posidonia oceanica* in the Mediterranean Basin. *Mar. Biol.*, **120**: 9-15.

Romero, J., G. Pergent, C. Pergent-Martini, M.A. Mateo, C. Regnier, 1992: The detritic compartment in a *Posidonia oceanica* meadow: litter features, decomposition rates and mineral stocks. P.S.Z.N.1: *Marine Ecology,* **13** (1): 69-83.

Ruggieri, G., A. Unti, M. Unti, M.A. Moroni, 1975: La calcarenite di Marsala (Pleistocene inferiore) ed i terreni contermini. *Boll. Soc. Geol. It.*, **94**: 1623-1657.

Russo, G. F., E. Fresi & D. Vinci, 1985: The hand-towed net method for direct sampling in *Posidonia oceanica* beds. *Rapp. Comm. Int. Mer Médit.*, **29** (6): 175-177.

Russo, G. F., D. Vinci, M. Scardi & E. Fresi, 1991: Mollusc syntaxon of foliar stratum along a depth gradient in a *Posidonia oceanica* bed:III. A year' s cycle at Ischia Island. *Posidonia Newsletter,* **4** (1): 15-25.

Templado, J., 1984: moluscos de las praderas de Posidonia oceanica en las costas de Cabo de Palos (Murcia). *Inv. Pesq.*, **48** (3): 509-526

Toccaceli, M. & Riggio S. , 1989: Note bibliografiche sulle fanerogame marine delle coste siciliane. *Oebalia*, **15** (1): 279-286

Toccaceli, M. & Alessi M.C., 1989: Cartografia biocenotica delle praterie a fanerogame marine della Baia di Carini (Sicilia nord-occidentale). *Oebalia*, **15** (1): 341-344.

Toccaceli, M., 1990: Il recif-barriere di *Posidonoa oceanica* (L.) Delile della baia di Carini (Sicilia nord-occidentale) *Oebalia*, 16, suppl. **2**: 781-784..

UNI 8783 1985: Unificazione italiana. Norme per il settore della Pesca. *Ente Nazionale Italiano di Unificazione*: 242 pp.