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The thermophilic Asteroidea *Ophidiaster ophidianus* on the NW Mediterranean coasts : evidence of frequency increase

Jean-Georges HARMELIN1 & 2, Sandrine RUITTON1 & 2

[1] Centre d'Océanologie de Marseille, Université de la Méditerranée, Marseille
[2] GIS Posidonie, Parc scientifique et technologique de Luminy, case 901, 13288 Marseille Cedex 09
Contacts: jean-georges.harmelin@univmed.fr

Abstract. The purple starfish *Ophidiaster ophidianus* (Lamarck, 1816) is a thermophilic Atlanto-Mediterranean species whose Mediterranean distribution range (reviewed here) was restricted to the warmer sectors of the basin. Its occurrence on the northern, colder, continental coasts, which was formerly very occasional, is now more and more frequent as attested by the number of sightings recorded by divers along the coasts of Provence and the French Riviera. These scattered individuals may come from a single pulse recruitment. However, as this starfish may be considered as a reliable indicator of climate warming, its monitoring should be undertaken in order to record patterns of change in its abundance and the possible establishment of a viable population in the northern Mediterranean.

***Résumé*. L'étoile de mer thermophile *Ophidiaster ophidianus* sur les côtes NO de la Méditerranée : évidences de l'accroissement de sa fréquence.** L'étoile de mer pourpre Ophidiaster ophidianus (Lamarck, 1816) est une espèce atlanto-méditerranéenne thermophile dont la distribution en Méditerranée, revue ici, était restreinte aux secteurs les plus chauds du bassin. Sa présence sur les côtes continentales septentrionales plus froides, qui était autrefois très occasionnelle, est maintenant de plus en plus fréquente, comme l'atteste le nombre de rencontres par des plongeurs sur les côtes de Provence et de la Riviera française. Ces individus dispersés peuvent provenir d'un seul événement exceptionnel de recrutement. Toutefois, comme cette étoile de mer peut être considérée comme un indicateur fiable du réchauffement climatique, son suivi devrait être entrepris afin d'enregistrer les changements dans son abondance et l'établissement éventuel d'une population viable dans le nord de la Méditerranée.

INTRODUCTION

The Mediterranean marine biota reacts strikingly to global climate warming through three kinds of response: (i) mortality events affecting vulnerable elements during summer thermal anomalies, (ii) increased immigration of non-indigenous species from the Red Sea and warm regions of eastern Atlantic, and (iii) changes in the distribution patterns

of many native taxa, mostly thermophilic southern species, which present a northwards expansion of their geographic distribution range (synthesis in CIESM, 2008; Lejeusne *et al*., 2010). *Ophidiaster ophidianus* (Lamarck, 1816) is typically one of those Atlanto-Mediterranean thermophilic species (Pérès and Picard, 1964; Tortonese, 1975). It is a conspicuous starfish, large (diameter up to 35 cm) and brightly coloured in red, dark carmine, purple or orange with sometimes darker spots. It is characterised by long cylindrical arms, slightly narrower near the disk, which is typically small (Koehler, 1924; Tortonese, 1965). Its general geographic distribution pattern shows that it is excluded from cold regions and is thus a good indicator of climate-related biogeogeographic boundaries (Pérès and Picard, 1964). It is registered in Annex II (strictly protected fauna species) of the Bern and Barcelona conventions.

Recent observations on the French Mediterranean coast indicate that the range of *O. ophidianus* is expanding in the NW Mediterranean. The available literature data on the distribution of this starfish and new data from field observations by divers are analysed here.

MATERIAL AND METHODS

The search for information on unpublished occurrences of the purple starfish has been undertaken on the basis of enquiries among a network of reliable diving observers and photographers and by means of web forums such as Biosub and Natura Mediterranea. The web site of the French Diving Federation (FFESSM), DORIS (Doris, 2009) has been an invaluable source of validated information. It provides for many coastal species, including *O. ophidianus*, a description and series of underwater pictures with precise data on locality, habitat and date of sighting.

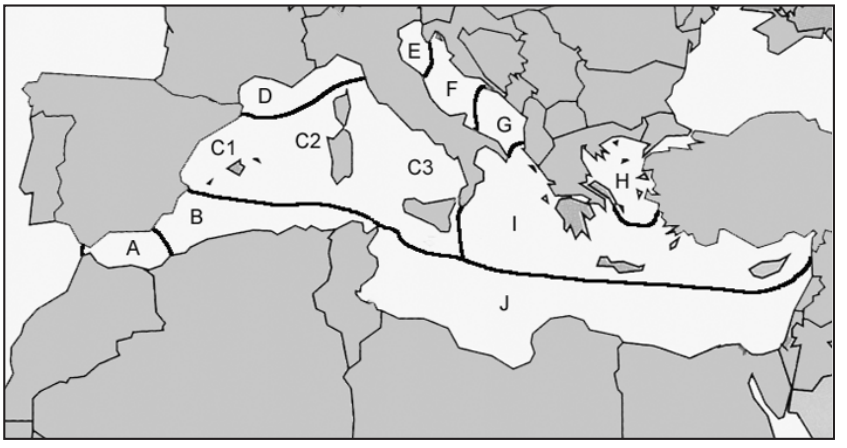

Figure 1. Biogeographic sectors within the Mediterranean. Redrawn from Bianchi and Morri (2000) with modifications: sector C segmented in C1, C2 and C3.

RESULTS

1 - Geographical distribution range: status from literature

1.1 - Atlantic Ocean. The purple starfish *Ophidiaster ophidianus* is fundamentally an eastern Atlantic species whose distribution in this ocean ranges from the Azores archipelago and southern Portugal in the north to the Gulf of Guinea (Sao Tome) and St Helena in the south (Koehler, 1924; Molinier and Picard, 1956; Tortonese, 1965). Thus, this Atlantic distribution range covers warm-temperate and sub-tropical areas of the Lusitanian and Mauretanian regions (Azores being at the boundary between these two regions) as well as tropical and equatorial areas of the Senegalese region. Although present in the Madeira Archipelago (Saldanha, 1997) and Canary Islands (Moreno-Batet and Bacallado, 1980), it would appear to be absent from the Atlantic coasts of Morocco (Pérez-Ruzafa and López-Ibor, 1988). The high frequency of this starfish in Cabo Verde islands from 5 to 20 m depth recorded by Entrambasaguas *et al.* (2008) and Pérez-Ruzafa *et al.* (2003) suggests that W. Africa may be the centre of its geographical distribution.

1.2 - Mediterranean Sea. On the basis of the distribution pattern of *O. ophidianus* in the eastern Atlantic, Pérès and Picard (1964) categorised it as a Senegalese species whose immigration into the Mediterranean was restricted to the warm, central part of the western basin. The Naples area was then considered to be the northward limit of its population on the eastern side, similarly to the scleractinian *Astroides calycularis*. The Mediterranean geographical records were compiled from the literature and have been sorted below according to the biogeographical sectors defined by Bianchi (2000) and slightly modified here (Fig. 1).

Sector A – The purple starfish is relatively common around the Alboran Sea, including the Moroccan coast (Mellila and Chafarinas Is.: Moreno Lampreave and Pérez-Ruzafa, 2008, Alboran Is.: Templado and Calvo, 2006), W Algeria (Habibas Is.: JGH personal observations, 2007) and the coast of Andalusia (Moreno Lampreave and Pérez-Ruzafa, 2008; Ocaña and Pérez-Ruzafa, 2004).

Sector B – *O. ophidianus* occurs on the coast of Algeria and Tunisia (Molinier and Picard, 1956; Pérès and Picard, 1964; Algiers: P. Chevaldonné observations, 2006). Although not listed by Cherbonnier (1956) in his survey of the Tunisian echinoderms, it was the most frequent starfish recorded in 1986 on hard-substrates at Zembra Is. (N Tunisia), from the photophylic algal community (6 m) to the coralligenous bottoms (45 m) (Boudouresque, 1986; Harmelin, 1986; Jeudy de Grissac *et al.*, 1986). In Spain, it is relatively frequent along the coasts of Almeria, Cabo de Gata and Murcia (Calvin *et al.*, 2001; Moreno Lampreave and Pérez-Ruzafa, 2008; Pérez-Ruzafa and López-Ibor, 1987; J.A. Garcia-Charton personal communication).

Sector C1 – *O. ophidianus* is present but not frequent in the Columbretes Is. (Templado *et al.*, 2002). It has seemingly not been recorded north of Cabo de la Nao (A. Pérez-Ruzafa, personal communication), nor in Catalonia. It is common in the Balearic Islands (Cabrera Is.: Moreno *et al*., 2001; Moreno Lampreave and Pérez-Ruzafa, 2008; Minorca Is.: JGH personal observations, 1998).

Sector C2 – *O. ophidianus* is present in W Sardinia (Tortonese, 1965), N Sardinia (photographic record by A. Colacino at La Maddalena, 9 m: web forum Natura Mediterranea) and Capraia Is. (Bianchi and Morri, 1994). In W Corsica, it was recorded for the first time in 1990 at Scandola (Francour *et al.*, 1994) and is now encountered more and more frequently as attested by photographic records available on the Doris website and other evidence (Scandola, 10 & 15 m: R. Graille, 2004 & 2006; N Galeria, 15m, V. Maliet, 10/2009; La Vacque, Cerbicales Is., 20 m, P. Melis, 06/04/2010).

Sector C3 – Long-standing presence at Naples, Salerno Gulf, Capri, Isola del Giglio, Sicily (Molinier and Picard, 1956; Pérès and Picard, 1964; Tortonese, 1965), Straits of Sicily (Gautier-Michaz, 1958), Malta (Tanti and Schembri, 2006).

Sector D – The purple starfish has occasionally been recorded in the Ligurian Sea, around the Portofino promontory in 1896, 1956 and 1964 (Bianchi and Morri, 1994; Tortonese, 1957, 1965), at Sestri Levante and Villefranche (Tortonese, 1965).

Sector E – No observation.

Sector F – Central Adriatic: presence from Kornati Archipelago to Mljet (AndriÇ, 1999; Zavodnik, 2003), common at Vis Is. (Komitza: JGH personal observations, 2005).

Sector G – Southern Adriatic: records from Montenegro (Ka‰Çelan, 2008) and Albania (map and references in Zavodnik, 2003).

Sector H - Records from two stations in the northern Aegean Sea (Antoniadou *et al.*, 2006).

Sector I – Ionian Sea: (Gjiknuri, 1985; photographic record by Roberto Pillon at Lefkada Is.: web forum Natura Mediterranea). An occasional occurrence of *O. ophidianus* at Rhodes was noted by Pérès and Picard (1964) and Tortonese (1965) and at Cyprus (Demetropoulos and Hadjichristophorou, 1976).

Sector J – No observation.

2 - Sightings of *O. ophidianus* on the French Mediterranean coast

Apart from the museum specimen from Villefranche recorded by Tortonese (1965) without indication of collection date, there was no

record of *O. ophidianus* from the French Riviera until recently. For example, it was lacking from visual censuses of echinoderms undertaken in the Marseille area (Harmelin *et al.*, 1981), around the Embiez archipelago (Escoubet, 1982) and the Hyères islands (Augier, 1983; Harmelin *et al.*, 1980; Hereu *et al.*, 2005), and from benthos diving surveys around Levant Is. (Ruitton *et al.*, 2007) and Porquerolles (Ruitton *et al.*, 2005). However, indisputable evidence (photographic records) of the presence of the purple starfish along the continental French Mediterranean coast, from Marseille to Cannes, has been available since 1999 and is more and more frequent (Tab. I). Eleven sightings have been recorded in Provence, including four in the national Park of Port-Cros. These records correspond to nine different sites from 8 m to below 60 m depth.

Table I. – Recent records of *O. ophidianus* on the continental Mediterranean coast of France. Observer[1]: photos available on the Doris web site (Doris, 2009), observer[2]: photo published in Harmelin and Bassemayousse (2008: 115), observer[3]: photos in personal collection. Coordinates were determined approximately from the location of sightings on Google Earth maps. md: missing data.

Location and depth	Coordinates	Date	Observer
Marseille, Veyron, 18 m	43°12'28 N 5°15'13 E	06/2006	H. Mennella, E. Sauvant[1]
Marseille, Riou, Impérial Milieu, 13 m	43°10'17 N 5°23'36 E	07/1999	S. Sartoretto
La Ciotat, 20 m	43°09'51 N 5°35'56 E	10/2006	R. Graille[1]
La Ciotat, Cassidaigne, > 60 m	43°08'52 N 5°32'24 E	2000s	G. Carrodano
Embiez Archipelago	43°04'40 N 5°45'43 E	md	D. Rebillard
Embiez Archipelago, 30 m	43°04'29 N 5°45'46 E	8/04/2010	D. Rebillard
Port-Cros, Gabinière Is., 22 m	42°59'21 N 6°23'46 E	06/2006	F. André[1]
Port-Cros, Gabinière Is., 8 m	42°59'21 N 6°23'41 E	08/2009	S. Ruitton[3]
Port-Cros, La Dame, 10 m	43°00'13 N 6°25'22 E	09/2007	F. Bassemayousse[2]
Port-Cros, La Galère, 10 m	43°01'13 N 6°24'33 E	07/2006- 2008	I. Masinski
Cannes, Lérins St Honorat Is., 20 m	43°30'29 N 7°04'00 E	09/2005	M. Nemoz[3]

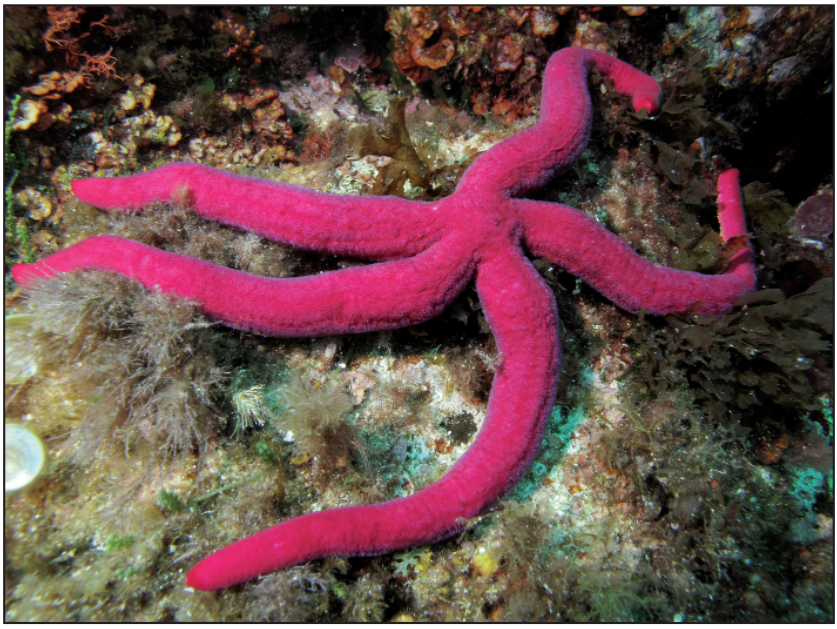

Figure 2. *Ophidiaster ophidianus* at Port-Cros, La Gabinière, 8 m, August 2009. Photo S. Ruitton.

DISCUSSION

Ophidiaster ophidianus has long been considered as one of the most typical thermophilic species in the Mediterranean (Pérès and Picard, 1964; Tortonese, 1965). Although still moderate, its present-day occurrence along the French Mediterranean coast is rising. This is a conclusive step in its northwards advance, which was predictable considering the age of its settlement in Corsica, first detected 20 years ago (Francour *et al.*, 1994).

The actual abundance of *O. ophidianus* along the French Mediterranean coast is probably underestimated, partly because of its superficial resemblance to two common red starfishes, *Echinaster sepositus* and *Hacelia attenuata*, which may mislead inexperienced observers, and also because of insufficient transfer of information from divers. The case of this conspicuous starfish bears out the necessity of increasing the awareness of potential observers of the importance of recording changes in marine communities (CIESM, 2008). The sighting of this species at the same site (Gabinière Is.) by two different observers after an interval of three years (Tab. I) raises at least two questions: (i) is it the same individual?, and (ii) why has this spectacular species only been sighted twice in three years at this site that is highly frequented by professional and amateur naturalist divers? Considering the poor mobil-

ity of this starfish, it is highly probable that this long-lived starfish exhibits long-term site fidelity, such as observed with solitary specimens of *Astrospartus mediterraneus* (JGH, unpublished). In addition, for the same reason, it is likely that its recording at two sites on the southern side of Port-Cros (Gabinière Islet and La Dame), 3 km apart from each over, concerns two different individuals.

The present status of this species on the continental coasts of France consists essentially of scattered specimens observed between 2006 and 2009. This distribution pattern may correspond to two different scenarios: (1) all observed specimens of this long-lived starfish stem from a single exceptional larval influx and settlement event or (2) the supply in larvae from marginal populations has been repeated several times during the last decade(s) leading to the colonisation of different sites along the French coast. As stressed by Astraldi *et al.* (1995), records of long-lived species do not provide information on the start of colonisation. This is particularly obvious when colonisation depends only on the supply of pelagic larvae and when juveniles are cryptic and seldom observable, as is the case of most echinoderms.

In the absence of new pulse settlement (case 1), the present group of scattered individuals will not expand and may remain a pseudopopulation in the sense of Beklemishev (Bouchet and Taviani, 1992), *i.e.* a group of individuals unable to reproduce (here, because of individual scattering and/or inadequate environmental conditions) and whose persistence depends on a constant supply of larvae from remote source populations. In the second case, an increased individual density resulting from repeated settlement events by allochthonous competent larvae would trigger successful reproduction within the group if other factors inducing gonad maturation and spawning are combined. Whatever the fate of the present group of individuals, its occurrence on the French Mediterranean coast raises the question of the location of the source population. Dispersal of larval recruits from upstream sources is largely determined by the duration of pelagic stages and oceanographic conditions. This larval parameter is not known in *Ophidiaster* but one may suppose that larvae of the purple starfish are of a Bipinnaria or Branchiolaria type, *i.e*. planktotrophic, as recorded in Ophidiasteridae (McEdward and Miner, 2001). This would imply a pelagic life of several weeks before settlement and possible drifting from remote source populations. Considering the E-W circulation of the Northern current (Millot and Wald, 1980), the spawning sites should stand east of Provence. The Ligurian Sea is a privileged source region as suggested by the past occurrence of *O. ophidianus* at Portofino and the increased occurrence of warm-water species in this sea (Astraldi *et al.*, 1995; Bianchi and Morri, 1993, 1994; Morri and Bianchi, 2001). Corsica and northern Sardinia, where this starfish is now relatively common, are also possible locations of source populations. Although direct larval drifting from the

Balearic population of *O. ophidianus* is unlikely considering the circulation in the W. Mediterranean (Millot and Taupier-Letage, 2005), one may consider that exceptional storm events may upset the regular dispersal patterns of pelagic larvae.

The record of *O. ophidianus* below 60 m depth (G. Carrodano, personal communication) near La Ciotat contrasts with its regular distribution pattern from near-surface to 20 m depth in warmer areas (e.g. Moreno Lampreave and Pérez-Ruzafa, 2008). The same paradoxical difference in depth distribution between cold and warm regions of the Mediterranean is observed in other species, such as the Asteroidea *Peltaster placenta* (Müller and Troschel). It might be related to the frequency of thermal stresses occurring at shallow depths during summer in northern regions (Harmelin, 2004).

This thermophilic starfish is a meaningful indicator of climate change and "meridionalization" of the northern Mediterranean (Bianchi, 2007; Bianchi and Morri, 2000; Francour *et al.*, 1994; Lejeusne et al., 2010). Monitoring the expansion of this key species in the NW Mediterranean is of primary interest and should be coupled to that of other conspicuous thermophilic echinoderms such as the holothurid *Holothuria sanctori* Delle Chiaje, the asteroids *Chaetaster longipes* (Retzius) and *P. placenta*, and the echinid *Centrostephanus longispinus* (Philippi).

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REFERENCES

ANDRIÀ M., 1999. – *Croatia's undersea world*. Cartterc d.o.o., Zagreb, 1-274.

ANTONIADOU C., VOULTSIADOU E., CHINTIROGLOU C., 2006. – Sublittoral megabenthos along cliffs of different profile (Aegean Sea, Eastern Mediterranean). *Belg. J. Zool*., 136 (1): 69-79.

ASTRALDI M., BIANCHI C.N., GASPARINI G.P., MORRI C., 1995. – Climatic fluctuations, current variability and marine species distribution: a case study in the Ligurian Sea (north-west Mediterranean). *Oceanologica Acta*, 18, 2: 139-149.

AUGIER H., 1983. – Contribution à l'inventaire des îles d'Hyères (Méditerranée, France). *Vie Mar*., 5: 1-11.

BIANCHI C.N., 2007. Biodiversity issues for the forthcoming tropical Mediterranean Sea. *Hydrobiologia*, 580: 7-21.

BIANCHI C.N., MORRI C., 1993. Range extension of warm-water species in the northern Mediterranean: evidence for climatic fluctuations? *Porcupine Newsletter*, 5 (7): 156-159.

BIANCHI C.N., MORRI C., 1994. Southern species in the Ligurian Sea (northern Mediterranean): New records and a review. *Boll. Mus. Ist. Biol. Univ. Genova*, 58-59: 181-197.

BIANCHI C.N., MORRI C., 2000. Marine biodiversity of the Mediterranean Sea: Situation, problems and prospects for future research. *Mar. Poll. Bull*., 40, 5: 367-376.

BOUCHET P., TAVIANI M., 1992. – The Mediterranean deep-sea fauna: pseudopopulations of Atlantic species? *Deep-Sea Research*, 39, 2: 169-184.

BOUDOURESQUE C.F., HARMELIN J.G., JEUDY de GRISSAC A., 1986. *Le benthos marin de l'île de Zembra (Parc National, Tunisie).* UNEP-IUCN RAC/SPA, Gis Posidonie Publ., Fr., 1-199.

CALVÍN J.C., MARTINEZ INGLÉS A.M., GARCÍA MORENO P., 2001. - *Especies singulares en el litoral de Murcia. Estado actual y lineas de actuación para su conservación.* Consejería de Agricultura, Agua y Medio Ambiente, Región de Murcia, 1-64..

CHERBONNIER G., 1956. – Les échinodermes de Tunisie. *Bull. Sta. Océanogr. Salammbô*, 53: 1-23.

CIESM, 2008. – Climate warming and related changes in Mediterranean marine biota. CIESM Workshop Monographs, F. BRIAND, ed., Monaco: 1-152.

DEMETROPOULOS A., HADJICHRISTOPHOROU M., 1976. – Echinodermata of Cyprus. Crinoidea, Echinoidea, Asteroidea, Ophiuroidea. *Fish. Bull*., 4: 7-74.

DORIS, 2009. – Données d'observations pour la reconnaissance et l'identification de la faune et de la flore subaquatique. http://doris.ffessm.fr/. Novembre 2009.

ENTRAMBASAGUAS L., PÉREZ-RUZAFA A., GARCÍA CHARTON J.A., STOBART B., BACALLADO J.J., 2008. – Abundance, spatial distribution and habitat relationships of echinoderms in the Cabo Verde Archipelago (eastern Mediterranean). *Mar. Fresh. Res.*, 59: 477-488.

ESCOUBET P., 1982. – La faune marine de l'archipel des Embiez (Var, France). I. Echinodermes. 1° partie. Crinoïdes, Astérides, Echinides. *Vie Mar*., 4: 95-98.

FRANCOUR P., BOUDOURESQUE CH.-F., HARMELIN-VIVIEN M., HARMELIN J.G., QUIGNARD J.P., 1994. - Are the Mediterranean waters becoming warmer ? Information from biological indicators. *Mar. Poll. Bull.*, 28 (9): 523-526.

GAUTIER-MICHAZ M., 1958. – Résultats scientifiques des campagnes de la Calypso. Fascicule III. Echinodermes. *Ann. Inst. Océan.*, 34: 145-155.

HARMELIN J.G., 1986. Autres groupes zoologiques. *Le benthos marin de l'île de Zembra (parc national, Tunisie)*, UNEP-IUCN6RAC/SPA, C.F. BOUDOURESQUE, J.G. HARMELIN et A. JEUDY DE GRISSAC, ed., GIS Posidonie publ., Fr., 117-125.

HARMELIN J.G., 2004. - Environnement thermique du benthos côtier de l'île de Port-Cros (parc national, France, Méditerranée nord-occidentale) et implications biogéographiques. *Sci. Rep. Port-Cros natl. Park*, Fr., 20: 173-194.

HARMELIN J.G., BASSEMAYOUSSE F., 2008. – *Méditerranée. A la découverte des paysages sous-marins*. Chasse-Marée Glénat, Grenoble, 1-192.

HARMELIN J.G., BOUCHON C., DUVAL C, HONG J.S., 1980. - Les échinodermes des substrats durs de l'île de Port-Cros, Parc National (Méditerranée Nord-Occidentale). Eléments pour un inventaire quantitatif. *Trav. sci. Parc nat. Port-Cros*, 6: 25-38.

HARMELIN J.G., BOUCHON C., HONG J.S., 1981. - Impact de la pollution sur la distribution des échinodermes des substrats durs en Provence (Méditerranée Nord-Orientale). *Téthys*, 10 (1): 13-36.

HEREU B., LINARES C., DIAZ D., TEIXIDOR N., ZABALA M., 2005. *Inventaire et densité des échinodermes de Porquerolles, avec taille moyenne de l'oursin Paracentrotus lividus dans les secteurs clés.* Rapport PNPC-Universitat de Barcelona, 1-52.

JEUDY DE GRISSAC A., BEN MAIZ N., BEN MUSTAPHA K., BOUDOURESQUE C.F., HARMELIN J.G., KARTAS F., 1986. Caractères généraux du benthos du parc marin de l'île de Zembra (Tunisie). *Rapp. Comm. int. Mer Médit*., 30 (2): 17.

KASCELAN S., 2008. – Spatial and seasonal distribution of echinoderms in the Boka Kotorska Bay. *Bull. Nat. Hist. Mus*., 1: 149-160.

KOEHLER R., 1924. – *Les échinodermes des mers d'Europe. Tome premier*. Gaston Doin Edit., 1-362.

LEJEUSNE C., CHEVALDONNÉ P., PERGENT-MARTINI C., BOUDOURESQUE C.F., PEREZ T., 2010. Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. *Trends in Ecology & Evolution*, 25 (4): 250-260.

McEDWARD L.R., MINER B.G., 2001. – Larval and life-cycle patterns in echinoderms. *Can. J. Zool*., 79 (7): 1125-1170.

MILLOT C., WALD L., 1980. - The effect of Mistral wind in the Ligurian current near Provence. *Oceanol. Acta*, 3, 4: 399-402.

MILLOT C., TAUPER-LETAGE I., 2005. – Circulation in the Mediterranean Sea. *Hdb. Env. Chem*., 5K: 29-66.

MOLINIER R., PICARD J., 1956. – Aperçu bionomique sur les peuplements marins littoraux des côtes rocheuses méditerranéennes du Sud de l'Espagne. *Bull. Sta. Centr. Aquic. Pêche Castiglione*, N.S., 8: 251-268.

MORENO-BATET E., BACALLADO J.J., 1980. – Sur une collection d'astéries de l'Archipel des Canaries. *Echinoderms: Present and Past*, M. JANGOUX ed., A.A. Balkema, Rotterdam: 123-126.

MORENO J., BALLESTEROS E., AMENGUAL RAMIS J., 2001. – *Archipiélago de Cabrera. Parque nacional*. Ministerio de Medio Ambiente. Lunwerg, Barcelona, 1-222.

MORENO LAMPREAVE D., PÉREZ-RUZAFA A., 2008. *Ophidiaster ophidianus* (Lamarck, 1816), *Libro Rojo de los Invertebrados de Andalucía. Tomo 2*, J. BAREA-AZCÓN, E. BALLESTEROS-DUPERÓN and D. MORENO, ed., Consejería de Medio Ambiente, Junta de Andalucía, Sevilla: 621-625.

MORRI C., BIANCHI C.N., 2001. – Recent changes in biodiversity in the Ligurian Sea (NW Mediterranean): is there a climatic forcing? *Structure and processes in the Mediterranean ecosystems*, F.M. FARANDA, L. GUGLIELMO andG. SPEZIE, ed., Springer Verlag, Milan: 375-384.

OCAÑA A., PÉREZ-RUZAFA A., 2004. Los equinodermos de las costas andaluzas. *Acta Granatense*, 3: 83-136.

PÉRÈS J.M., PICARD J., 1964. – Nouveau manuel de bionomie benthique de la mer Méditerranée. *Rec. Trav. Sta. Mar. Endoume*, Bull. 31, 47: 1-137.

PÉREZ-RUZAFA A., LÓPEZ-IBOR, 1988. – Echinoderm fauna from the south-western Mediterranean and biogeographic relationships. *Echinoderm biology*, R.D. BURKE, MLADENOV P.V., LAMBERT P., PARSLEY R.L., ed., A.A. Balkema, Rotterdam: 355-361.

PÉREZ-RUZAFA A., ENTRAMBASAGUAS L., MARCOS C., BACALLADO J.J., GARCÍA CHARTON J.A., 2003. – Spatial relationships of the echinoderm fauna of Cabo Verde islands: A multi-scale approach. *Echinoderm Research 2001*, J.P. FERAL and B. DAVID, ed., Swets & Zeitlinger publ., Lisse: 31-39.

PINA J.A., PÉREZ-RUZAFA A., 1984. - Aportación al catálogo de equinodermos del litoral murciano. *Actas di IV Simp. Iber. de Estud. do Benthos Marinho*, III: 269-276.

RODRIGUEZ J., 1980. – Echinoderms (except Holothuroidea) of the Southern Mediterranean coast of Spain. *Echinoderms: Present and Past*, M. JANGOUX, ed., A.A. Balkema, Rotterdam: 127-131.

RUITTON S., BONHOMME P., CADIOU G., HARMELIN J.G., PEREZ T., 2005. *Inventaire du patrimoine naturel sous-marin des faces Est et Sud de Porquerolles – Substrats durs et herbier à Posidonia oceanica. Rapport final.* Contrat Parc national de Port-Cros & GIS Posidonie. GIS Posidonie publ., Fr., 1-63.

RUITTON S., BONHOMME P., CADIOU G., EMERY E., HARMELIN J.G., HERVE G., KANTIN R., 2007. – *Etude et cartographie des biocénoses du milieu marin de l'île du Levant (Var, France). Phase 3 – Rapport final.* Contrat Parc national de Port-Cros & GIS Posidonie – IFREMER, GIS Posidonie publ., Fr., 1-163.

SALDANHA L., 1997. – *Fauna submarina atlântica. Portugal continental, Açores, Madeira*. 3ª Ediçâo. Publicaçoes Europa-América, Sintra, 1-364.

TANTI C.M., SCHEMBRI P.J., 2006. – A synthesis of the echinoderm fauna of the Maltese islands. *J. Mar. Biol. Ass. U.K*., 86: 163-165.

TEMPLADO J., CALVO M., GARCÍA-CARRASCOSA A.M., BOISSET F., JIMÉNEZ J., 2002. – Flora y fauna de la Reserva Marina de las Islas Columbretes. Secretaría General de Pesca Marítima. MAPA, Madrid, 263 p.

TEMPLADO J., CALVO M. (ed.), 2006. *Flora y fauna de la Reserva Marina y Reserva de Pesca de la isla de Alborán.* Secretaría General de Pesca Marítima. MAPA, Madrid, 1-269.

TORTONESE E., 1957. – Elementi termofili nell'asterofauna del mar Ligure (*Ophidiaster*, *Hacelia*, *Chaetaster*). *Ann. Mus. Civ. St. Nat. Genova*, 69: 94-98.

TORTONESE E., 1965. – *Echinodermata*. Fauna d'Italia, VI. Edizioni Calderini, Bologna: 1-422.

ZAVODNIK D., 2003. – Marine fauna of Mljet National Park (Adriatic Sea, Croatia). 2. Echinodermata. *Acta Adriat*., 44 (2): 105-160.