TABLE 1
Geographical Sub-Areas (GSAs) of the Mediterranean discussed in this review

Number	Name	Estimated depth range (and jurisdiction)
1	Northern Alboran Sea	Some areas between 400 and 1 000 m, minor areas of 0–400, the rest below 1 000 m; likely to be national waters
5	Balearic Islands	Area largely deeper than 1 000 m, with smaller areas of between 400 and 1 000 m; likely to be national waters
6	Northern Spain	Largely below 1 000 m, minor areas between 400 and 1 000 m; likely to be national waters
7	Gulf of Lions	Only a small portion between 400 and 1 000 m and the rest 0–400 m or below 1 000 m; likely to be national waters
9	Ligurian and Northern Tyrrhenian Sea	Portions below 1 000 m, minor areas between 400 and 1 000 m and portions above 400 m; likely to be national waters
11	Sardinia	Only minor areas of between 400 and 1 000 m; likely to be national waters
16	South/Strait of Sicily	On continental shelf; minor areas of below 1 000 m, some areas of 400–1 000 m
17	Northern Adriatic Sea	Only 0–400 m depth range; likely to be national waters
18	Southern Adriatic Sea	Portion of areas between 400 and 1 000 m, as well as below 1 000 m; likely to be national waters
19	Western Ionian Sea	Primarily below 1 000 m with small areas from 400 to 1 000 m
20	Eastern Ionian Sea	Primarily below 1 000 m
21	Southern Ionian Sea	Larger areas between 400 and 1 000 m; likely to be national waters
22	Aegean Sea	Portion of below 1 000 m as well as portions of between 400 and 1 000 m; likely to be national waters
24	North Levant	Largely below 1 000 m
25	Cyprus	A significant portion of between 400 and 1 000 m; likely to be national waters
26	South Levant	Largely below 1 000 m, portions of 0–400 m and small areas of between 400 and 1 000 m
27	Levant	Possibly territorial waters of neighbouring countries, mainly below 1 000 m; likely to be national waters

Note: this table was prepared based on the information in the review. Its purpose is solely to identify deep-sea areas by GSA. It is not aimed at addressing jurisdictional matters.
Source: FAO maps.

DESCRIPTION OF DEEP-SEA BOTTOM FISHERIES IN THE HIGH SEAS

The Mediterranean has been addressed in a different manner from the other regions presented in this review because of the particular issue of identification of the high seas in the region. The 2007 FAO Questionnaire on High Seas Deep-sea Fisheries (hereinafter referred to as the FAO Questionnaire: see Appendix A) was therefore not sent to countries with a bottom fishing fleet exclusively fishing in the Mediterranean. This regional review was carried out through a desktop study and focuses on the Mediterranean Sea and it does not include deep-sea fisheries in the Black Sea.

Through consultations with experts on deep-sea fisheries in the Mediterranean, a working definition for the purpose of this review was developed: those fisheries on the slope of the continental shelf and on the sea bed, between 400 and 1 000 m in depth, continental shelf excluded. In addition, it was decided to focus on two primary fisheries, as described below, in the deep seas, and not necessarily in the high seas because of the difficulty in defining high seas in the region, which have been the area of primary interest.

The two commercially important deep-sea bottom fisheries described in this review are the multispecies fishery for European hake (*Merluccius merluccius*)[5] and the

[5] In fact, the European hake has two subspecies – one in the Atlantic and one in the Mediterranean. In this review, the focus is on the Mediterranean subspecies; *Merluccius merluccius smiridus*. However, for simplicity it is referred to as European hake (*Merluccius merluccius*).

directed fisheries for red shrimps (*Aristaeomorpha foliacea* and, in particular, *Aristeus antennatus*).

History of fisheries

Although the Mediterranean coastal states have a long history of fishing, deep-sea fishing only began in the first decades of the last century, as a result of the development of new technology that made fisheries in deeper waters possible. For example, red shrimps became the target of deep-water bottom trawl fishing in the Ligurian Sea in the 1930s (Sardà *et al.*, 2004).

In the central Mediterranean, preceding the collapse of the *A. foliacea* and *A. antennatus* stocks in the late 1970s, exploitation of these species had progressively been decreasing. Fishing of *A. antennatus* resumed following signs of stock recovery in 1985 (Orsi Relini and Relini, 1988, in Sardà *et al.*, 2004); however, *A. foliacea* was still extremely scarce and commercially insignificant in the late 1990s (Fiorentino *et al.*, 1998, in Sardà *et al.*, 2004). Suggested causes of the collapse included overfishing together with environmental decay, hydrology, failure of recruitment and parasitic attack on already stressed stocks (Orsi Relini and Relini, 1985; Relini and Orsi Relini, 1987, both in Sardà *et al.*, 2004).

Current fisheries

Fisheries down to a depth of 700 m have been common since the middle of the last century, and bottom trawl fisheries currently extend to almost 1 000 m, but grounds below this depth are considered beyond the reach of fishing boats (Sardà *et al.*, 2004). In addition, as will be explained in the section on Conservation and management measures, there is a GFCM ban in place on fishing with towed dredges and trawlnets below 1 000 m.

Two of the deep-sea demersal target species of greatest commercial value are European hake and blue and red shrimp (*Aristeus antennatus*) (see Table 2 and Figure 1). Other deep-water shrimp species, such as the giant red shrimp (*Aristaeomorpha foliacea*), are also a target species but are often grouped together in catch reports. For example, catch reported to FAO as "blue and red shrimp" may also include giant red shrimp. Therefore, although the discussion in this review will largely focus on *Aristeus antennatus*, it is possible that this also includes *Aristaeomorpha foliacea*, even when not referred to specifically. Furthermore, sometimes both of these species are reported together as Aristeid shrimps nei.

In Mediterranean terms, the species described here can be called deep-sea species, although they might not occur in waters as deep as in other deep-sea high seas fisheries around the world. Orsi Relini *et al.* (2002) suggest that the hake distribution in the Mediterranean Sea has a wide range – from 25 to 1 000 m. However, hake is mainly abundant at depths ranging from 100 to 400 m. The blue and red shrimp prefer a depth range of 501 to 800 m, but can

TABLE 2
Some of the main species targeted by deep-sea fisheries in the Mediterranean

Common name	Scientific name
Main target species – trawl fisheries	
European hake	*Merluccius merluccius*
Blue and red shrimp	*Aristeus antennatus*
Giant red shrimp	*Aristaeomorpha foliacea*
Main target species – gillnet and longline fisheries	
European hake	*Merluccius merluccius*
Associated species	
Norway lobster	*Nephrops norvegicus*
Deep-water rose shrimp	*Parapenaeus longirostris*
Blackbelly rosefish (blue-mouth redfish)	*Helicolenus dactylopterus*
Others species (mainly discarded)	
Greater forkbeard	*Phycis blennoides*
Four-spot megrim	*Lepidorhombus boscii*
Golden shrimp	*Plesionika martia*
Horned octopus (curled octopus)	*Eledone cirrosa*
European conger	*Conger conger*
Blue whiting	*Micromesistius poutassou*

Sources: GFCM SCSA, 2003; D'Onghia *et al.*, 2003; Sardà *et al.*, 2004; EC, 2002.

be found at both shallower and deeper depths (Cau *et al.*, 2002).

Trawl fisheries for red shrimps

The trawl fisheries for red shrimps take place on sandy, muddy bottoms and Cau *et al.* (2002) suggest that the blue and red shrimp is more abundant in the west and the giant red shrimp in the east.

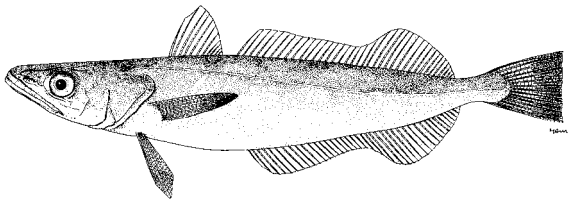
In the central Mediterranean, the main fisheries targeting red shrimps are located along the Italian Ionian Sea (GSA 19, see Map 2). Fishing takes place from coastal waters to depths of 700 to 750 m (Sardà *et al.*, 2004) and is potentially largely located in the deep seas.[6] The Strait of Sicily and southern Sardinia (GSAs 16 and 11) constitute the location for the main *A. foliacea* fisheries. *A. antennatus* is mostly caught in the western Mediterranean and in the Ionian Sea (GSAs 19, 20 & 21) Although the red shrimp fisheries are often distinct, there is some degree of overlapping. (Bianchini and Ragonese, 1994; Sardà *et al.*, 2001, both in Sardà *et al.*, 2004). In the Greek Ionian Sea (GSA 20), because of the steep bottoms and narrow continental shelf, fishing is mainly carried out only down to a depth of 400 m (Stergiou *et al.*, 1997, in Politou *et al.*, 2003); however, Politou *et al.* (2003) note that there is potential for expansion of, for example, red shrimp trawling into deeper waters and some occasional exploitation has begun.

In terms of catch volume in the different GSAs, around 300 tonnes of red and blue shrimp per year were landed from the Northern Alboran Sea (GSA 1) during the period 1976–2001. The last three years of that period indicated a decrease in catch. In the area of the Balearic Islands (GSA 5), landings averaged 170 tonnes between 2000 and 2003. Lastly, in the northern Spain area (GSA 6), the average annual landing around the year 2000 was 114 tonnes. (GFCM SCSA, 2003)

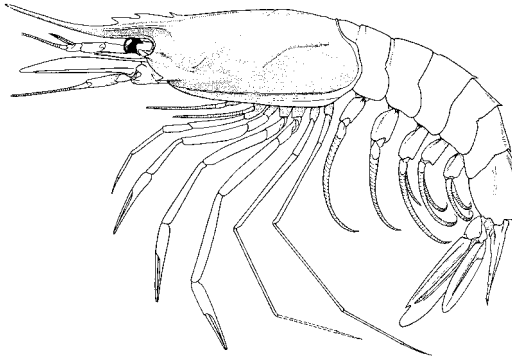
In Table 3, an attempt has been made to review catch reported by countries

FIGURE 1
Examples of species targeted by deep-sea fisheries in the Mediterranean

European hake (*Merluccius merluccius*)



Blue and red shrimp (*Aristeus antennatus*)



Source: FAO

TABLE 3
Catch (tonnes) of blue and red shrimp by country and GSA

Country	2002	2003	2004	2005
Adriatic (GSA 17[c] & 18[a])				
Italy[d]	114	130	134	119
Balearic Islands (GSA 5[a])				
Algeria	893	1 027	1 310	1 542
Spain	922	909	951	658
Ionian Sea (GSAs 19[b], 20[c] & 21[a])				
Albania	34	22	15	12
Italy[d]	1 081	1 542	698	1 732
Tunisia	20	–	6	149
Gulf of Lions (GSA 7[c])				
Spain	111	81	74	–
Sardinia (GSA 11[b])				
Italy[d]	573	737	714	1 323
Tunisia	31	24	37	14

Source: FAO, 2008.
[a] Likely to include deep-sea areas.
[b] Possibly includes deep-sea areas.
[c] Unlikely to include deep-sea areas.
[d] The Italian catch was reported as "Aristeid shrimps nei" by Italy but can be assumed to consist of *A. foliacea* and *A. antennatus*.
Note: this table is based on the most specific catch data that could be found. However, some of the catch of the above-mentioned species may not be included because of different, and less specific, ways of reporting catch, such as reporting as "crustaceans", or "shrimp/prawns".

[6] See Table 1 for a summarized analysis of each GSA mentioned.

from 2002 to 2005, in areas where trawling for blue and red shrimp is likely to take place below 400 m and off the continental shelf (assumptions made through GIS analysis). In this period, the largest amounts of catch were taken by Italy in the Ionian Sea and off Sardinia, and by Algeria and Spain off the Balearic Islands.

Hake fisheries

In the Mediterranean, European hake is caught in multispecies fisheries by bottom trawlers that operate over the continental shelf and slope (Goñi *et al.*, 2004), but also by gillnetters and set bottom longliners. Gillnetters and longliners are assumed to be operating in the deep sea (i.e. off the shelf and below 400 m). Similarly, bottom trawlers may also fish on the slope below 400 m and therefore in the deep seas.

In 2001, hake was exploited in the Gulf of Lions (GSA 7; only a small portion of which is potentially deep seas), by 113 French trawlers, 95 French gillnetters, 26 Spanish trawlers and 20 Spanish longliners. While the catch of the trawlers mainly included juveniles living on the continental shelf which are not considered to be in the deep seas, the gillnetters and longliners mainly exploited the adult part of the stock (spawners) living on the slope and in non-trawlable areas. During the period 1988–2001, 80 percent of the landings were done by trawlers. While the total number of trawlers decreased during this period (from 196 to 139), the number of gillnetters and longliners increased (from 20 to 95, and from 13 to 20 boats respectively). Total landings in 1988 were estimated at 2 941 tonnes compared with a similar 2 693 tonnes in 2001. It was also noted that discards periodically represented a significant part of the total hake catch, both in weight and in number. (GFCM SCSA, 2003)

In the Ligurian and North Tyrrhenian Sea (GSA 9), a hake fishery operated in 2001 to 2002, involving about 150 trawlers as well as a more limited number of vessels belonging to the artisanal fleet. In this area, annual landings are around 500 tonnes. Discards of undersized individuals can be considered important, although a reduction in discards and landings of undersized individuals did take place through enforcement of management measures. (GFCM SCSA, 2003)

In Table 4, an attempt has been made to review catch reported by countries from 2002 to 2005, in areas where fishing for European hake is likely to take place below 400 m and off the continental shelf (assumptions made through GIS analysis). In this period, the largest amounts of catch were taken by Italy (GSA 17, 18, 19, 20, 21 and 11), Greece (GSA 22), Spain (GSA 5) and France (GSA 7).

TABLE 4
Catch (tonnes) of European hake by country and GSA

Country	2002	2003	2004	2005
Adriatic (GSAs 17[c] & 18[a])				
Croatia	624	460	678	870
Italy	2 260	2 998	2 834	3 753
Serbia and Montenegro	18	18	19	19
Slovenia	2	5	1	3
Aegean (GSA 22[a])				
Greece	2 339	2 565	3 065	3 073
Balearic Islands (GSA 5[a])				
Algeria	209	31	22	12
Morocco	197	187	203	156
Spain	4 005	3 895	3 829	3 935
Gulf of Lions (GSA 7[c])				
France	2 663	2 452	1 291	1 019
Spain	701	–	334	428
Ionian Sea (GSAs 19[b], 20[c] & 21[a])				
Albania	200	384	473	267
Greece	591	604	683	798
Italy	4 251	4 297	4 680	7 121
Malta	–	–	–	–
Tunisia	638	242	740	520
Levant (GSAs 24[b], 26[a], 27[c] and possibly including 25[a] [Cyprus])				
Cyprus	3	11	10	28
Israel	68	60	39	36
Syrian Arab Republic	63	70	86	110
Sardinia (GSA 11[b])				
France	–	–	1	1
Italy	1 948	2 066	2 072	4 506
Tunisia	900	960	812	775

Source: FAO, 2008.
[a] Likely to include deep-sea areas.
[b] Possibly includes deep-sea areas.
[c] Unlikely to include deep-sea areas.

TABLE 5
Total catch (tonnes) by country and fishery for all GSA areas, 2002–2006

GFCM member country	Catch 2002 (tonnes)		Catch 2003 (tonnes)		Catch 2004 (tonnes)		Catch 2005 (tonnes)		Catch 2006 (tonnes)	
	Hake	Shrimp	Hake	Shrimp	Hake	Shrimp	Hake	Shrimp	Hake	Shrimp
Albania	200	34	384	22	473	15	267	12	280	18
Algeria	209	893	31	1 027	22	1 310	12	1 542	44	1 423
Croatia	624	–	460	–	678	–	870	–	920	–
Cyprus	3	–	11	–	10	–	28	–	23	–
France	2 663	–	2 452	–	1 292	–	1 020	–	1 031	–
Greece	2 930	–	3 169	–	3 748	–	3 871	–	4 794	–
Israel	68	–	60	–	39	–	36	–	18	–
Italy	8 459	1 768[a]	9 361	2 409[a]	9 586	1 546[a]	15 379	3 174[a]	18 570	3 623[a]
Malta	–	–	–	–	–	–	7	–	5	–
Montenegro[b]	18	–	18	–	19	–	19	–	19c	–
Morocco	197	–	187	–	203	–	156	–	958	–
Slovenia	2	–	5	–	1	–	3	–	3	–
Spain	4 706	1 033	3 895	990	4 163	1 025	4 363	696	4 766	1 004
Syrian Arab Republic	63	–	70	–	86	–	110	–	62	–
Tunisia	1 538	51	1 202	24	1 552	43	1 295	163	1 336	9
Total	21 680	3 779	21 140	4 472	21 872	3 939	27 436	5 587	32 829	6 077

[a] The Italian catch was reported as "Aristeid shrimp nei" by Italy but can be assumed to consist of *A. foliacea* and *A. antennatus*.
[b] The country has only been fishing/reporting capture this year, or this and last year. Before 2006, catch by Montenegro was reported as catch by the State Union of Serbia and Montenegro. From 2007, Montenegro alone is a GFCM member.
[c] FAO estimate.
Sources: FAO Fisheries and Aquaculture Information and Statistics Service – Global Capture Production 1950-2006; FAO, 2008.
Note: this table is based on the most specific catch data that could be found. However, some of the catch of the above-mentioned species may not be included because of different, and less specific, ways of reporting catch, such as reporting as "crustaceans", or "shrimp/prawns".

Catch and capacity summary

Table 5 provides an overview of the total catch of European hake and blue and red shrimp per country from 2002 to 2006 in the Mediterranean. However, there is no information available on whether this catch was caught in international waters or in waters under national jurisdiction. Overall, the main fishing states in terms of the blue and red shrimp appear to be Italy (with an average of 2 504 tonnes caught per year over this period), Algeria (average of 1 239 tonnes per year) and Spain (average of 949.6 tonnes per year). In the European hake case, the main fishing states appear to be Italy (average of 12 271 tonnes per year), Spain (average of 4 378.6 tonnes per year), Greece (average of 3 702.4 tonnes per year), France (average of 1 691.6 tonnes per year) and Tunisia (average of 1 384.6 tonnes per year).

Table 6 provides an overview of the different types and numbers of vessels (>15 m) that could possibly

TABLE 6
GFCM Authorised Vessels List (vessels of >15 m)

Country	Vessel type				Total
	Bottom trawlers[a]	Other trawlers[b]	Longliners (set longlines)	Gillnetters (set gillnets)	
Albania	117	6	–	possibly 1	123/124
Algeria	Vessel types not specified but a total of 543 (>15 m) vessels registered				543[c]
Croatia	–	151	–	–	151
Cyprus	15	–	–	–	15
France	28	89	–	5	122
Greece	323	–	45	19	387
Israel	No information				–
Italy	1 745	3	90	8	1 846
Malta	14	1	15	–	30
Montenegro	No information				–
Morocco	Vessel types not specified but a total of 577 (>15 m) vessels registered				577[c]
Slovenia	4	2	–	1	7
Spain	802	–	3	19	824
Syrian Arab Republic	No information				–
Tunisia	Vessel types not specified but a total of 760 (>15 m) vessels registered				760[c]

[a] Mostly bottom otter trawlers but also bottom beam trawlers, bottom pair trawlers and non-specified bottom trawlers.
[b] Including mid-water otter trawlers, mid-water pair trawlers and non-specified trawlers.
[c] Only a total number of vessels reported, without indication of type.
Source: GFCM Authorised Vessels List. http://www.gfcm.org/gfcm/topic/16163
Note: according to FAO Species Fact Sheets, these are the vessel types most likely to be catching European hake and blue and red shrimp.

be fishing for European hake and blue and red shrimp. It should be noted that this vessel information is based on general information in the GFCM Authorised Vessels List and thus it does not necessarily correspond to the number of vessels actually fishing for these species. Furthermore, this information only exists for 2008, as this was the year the list was made operational. Overall, it shows that Italy, Spain and Greece have the largest number of vessels, with fleets largely consisting of bottom trawlers.

Illegal, Unreported and Unregulated (IUU) fishing

IUU fishing in the Mediterranean is technically all fishing taking place by vessels that are not on the Authorised Vessels List. Pursuant to Recommendation GFCM/2005/2, GFCM established a Web-based Authorised Vessels List, for which Members provide information and updates. This "white list" complements a "black list" of vessels presumed to have carried out IUU fishing activities in the GFCM area, although the latter is still not in place.

In combating IUU fishing, the GFCM Members have adopted several measures including, for example, General Guidelines for a GFCM Control and Enforcement Scheme. In 2008, a binding Recommendation on a Regional Scheme on Port States Measures to Combat Illegal, Unreported and Unregulated (IUU) Fishing (Recommendation GFCM/2008/1) was adopted. This recommendation includes calls on contracting parties to:

- designate and publicize national ports to which foreign vessels may be permitted access and, to the greatest extent possible, ensure that every port designated and publicized has sufficient capacity to conduct inspections and take other port state measures in accordance with the Recommendation;
- before granting access to their designated ports, require the masters of vessels to notify the competent authorities of the port they wish to use at least 72 hours before the estimated time of arrival;
- not allow a vessel to use its ports for landing, transshipping or processing of fish if the vessel:
  (a) at the relevant time was engaged in fishing in the GFCM Area and was not flying the flag of a contracting party; or
  (b) has been sighted as being engaged in, or supporting, IUU fishing in the GFCM Area, unless the vessel can establish that the catch was taken in a manner consistent with relevant GFCM conservation and management measures;
- ensure that any vessel or vessel engaged in fishing related activities that enters into its port without prior authorization shall be automatically subject to inspection.

STATUS OF THE STOCKS, BYCATCH AND IMPACTS ON VULNERABLE MARINE ECOSYSTEMS

Status of target stocks

For European hake, the following assessments have been made in relation to the status of stocks. In 2002/3, stock assessments in the Gulf of Lions (GSA 7) and the Ligurian and Northern Tyrrhenian Sea (GSA 9) pointed at growth overexploitation, with a risk of recruitment overexploitation (GFCM SCSA, 2003). In 2005/6, growth overexploitation was reported for the Balearic Islands, northern Spain and the Gulf of Lions (GSA 5, 6 and 7), with a risk of recruitment overexploitation in the latter fishing area (GFCM SAC, 2006). In 2006/7, slight growth overexploitation was reported for the Balearic Islands, and the stock in Northern Spain was deemed to be overexploited (GFCM, 2008).

Corresponding management advice given by the Scientific Advisory Committee (SAC) has generally been related to reducing effort and improving trawl selectivity. However, as noted in SAC, it is necessary to have a clear idea of the overall effort level before reducing fishing effort. In addition, the programme of work set out for the Sub-

Committee on Stock Assessment (SCSA) for 2008 includes carrying out joint stock assessments of hake (*Merluccius merluccius*) and associated species in each GSA or a group of GSAs. (GFCM SAC, 2008).

For blue and red shrimp, the following assessments have been made on the status of stocks. In 2002/3, stock assessments in the Northern Alboran Sea (GSA 1), Balearic Islands (GSA 5) and northern Spain (GSA 6) pointed at stocks being fully exploited (GFCM SCSA, 2003). In 2005/6, stocks in the Balearic Islands and northern Spain were still deemed to be fully exploited (GFCM SAC, 2006) and, in 2006/7, stocks in northern Spain were overexploited according to the stock assessment (GFCM SAC, 2008).

Management advice given by SAC in relation to the blue and red shrimp has included the recommendation to reduce fishing effort by 10 percent (8 942 fishing days for a fleet of 130 vessels). In 2007, the implementation of 40 millimetre (mm) square mesh was recommended. (GFCM SAC, 2008)

Relevant conservation and management measures will be discussed in a later section.

Status of bycatch stocks

Little is known about the impact of fishing on benthic communities, non-target species and biodiversity in the region, as studies of the effects of fishing on deep-sea ecosystems have mostly focused on population structure and dynamics of target species.

Studies on discarding during deep-water trawling targeting red shrimps in the Ionian Sea showed that discarded catch represented a large fraction of the total catch (20–50 percent). It is suggested that this is almost exclusively a result of unwanted fish species and that discard rates seem to increase with the total catch and depth. In this fishery, discards of target species and other commercial species such as European hake, Norway lobster (*Nephrops norvegicus*), deep-water rose shrimp (*Parapenaeus longirostris*) and blackbelly rosefish (blue-mouth redfish) (*Helicolenus dactylopterus*) are negligible. However, species of low commercial value, such as greater forkbeard (*Phycis blennoides*), blue whiting (*Micromesistius poutassou*), four-spot megrim (*Lepidorhombus boscii*), golden shrimp (*Plesionika martia*), horned octopus (curled octopus) (*Eledone cirrosa*) or European conger (*Conger conger*), are discarded. (D'Onghia *et al.*, 2003; Sardà *et al.*, 2004)

Because of the multispecies nature of the demersal fishery targeting European hake and other species, there are a large number of associated species involved – for example, most of those mentioned in relation to the red shrimp fisheries (EC, 2002). Presumably, as in the red shrimp fisheries, the associated species of commercial value are likely to be retained, whereas those of low commercial value are possibly discarded to a larger extent. As mentioned above, stock assessments of European hake and associated species will be carried out during 2008.

Impacts on Vulnerable Marine Ecosystems (VMEs)

Unique and potentially vulnerable habitats of the Mediterranean include cold seeps, which are well represented along the Mediterranean Ridge, as well as deep-sea coral mounds and seamounts (Cartes *et al.*, 2004).

Although trawling, especially for red shrimp, generally takes place on muddy bottoms, fishing grounds of deep-water shrimp are also located around the perimeter of white-coral habitats, as well as on the margin of submarine canyons in the western Mediterranean (Sardà *et al.*, 2004). In addition to the possible direct effect of trawling on these VMEs, another problem related to trawling is the effects of sediment resuspension and related increased sedimentation, even at depths well beyond the ones trawled. It is suggested that although direct trawling (or other fishing methods) on coral reefs is the main obvious threat to the remaining Mediterranean deep-water coral reefs, trawling in the neighbouring bathyal mud bottoms could be equally deleterious

on these suspension feeders. Through a recent study, it was shown that sediment resuspension from trawlers working at 600–800 m depth reached a depth of 1 200 m. (Palanques *et al.,* 2004, in Cartes *et al.*, 2004)

It is suggested that most cold-water coral reefs in the Mediterranean are subfossil and date back to the last glacial age, a time of cooler seawater and better food availability. However, it is also noted that an indirect human impact has contributed to their decline – progressive human-induced forest destruction has led to the covering of white-coral mounds with a fine layer of sediment. One healthy and well developed deep-sea coral mound (consisting primarily of *Lophelia pertusa* and *Madrepora oculata*) is known to exist in the Ionian Sea and is now under protection, as mentioned in the section on Conservation and management measures. Such coral reefs, being natural deterrents to trawling, are believed to produce a positive spillover effect on the deep-water demersal resources fished on adjacent muddy bottoms. (Cartes *et al.*, 2004) Furthermore, in 2003, Maltese scientists discovered a second living and healthy deep-water coral bank, also consisting of *Lophelia* and *Madrepora*, at a depth of 390–617 m, some 20–40 km off the southern coast of Malta. This may also be a large reef and it is currently being investigated (Schembri *et al.*, 2007; GFCM SAC, 2007).

In terms of seamounts, although not comparable in numbers to certain Atlantic and Pacific areas, there are some seamounts located in the Gulf of Lions, the Alboran Sea, the eastern Tyrrhenian basin (to the south of the abyssal plain), and in the Levantine Sea (Cartes *et al.*, 2004). A total of 59 potential large seamounts has been identified for the Mediterranean (Kitchingman *et al.*, 2007). The biodiversity of this region is still poorly studied and largely unknown. One large seamount is the Eratosthenes Seamount, located off the south coast of Cyprus and west of Israel – 120 km in diameter and extending from the seafloor to within 800 m of the sea surface. (Cartes *et al.*, 2004) It is home to both *Aristaeomorpha foliacea* and *Aristeus antennatus*, as well as other species of commercial interest (Galil and Zibrowius, 1998, in Cartes *et al.*, 2004). However, overall there seem to be little fishing on seamounts in this region.

Finally, it should be noted that in the Mediterranean, anthropogenic threats to VMEs are not limited to fishing – other major threats include waste disposal (solid trash and other toxic compounds), pollution (Haedrich, 1996, in Cartes *et al.*, 2004), oil exploration/pipelines or, more indirectly, climate change (Danovaro *et al.,* 2001, in Cartes *et al.*, 2004).

CONSERVATION AND MANAGEMENT MEASURES

Target stocks

Various recommendations that are relevant to the target stocks of deep-sea high seas fisheries have been adopted by GFCM Members, in addition to the IUU measures. These include:

- REC-GFCM/29/2005/1 on the management of certain fisheries exploiting demersal and deep-water pelagic species – this recommendation calls on the Members to prohibit the use of towed dredges and trawlnet fisheries at depths beyond 1 000 m, as well as to adopt measures aimed at increasing the selectivity of demersal trawlnets, notably by immediate implementation of at least a 40 mm mesh size opening for the whole demersal trawl codend. Exploration and implementation of additional measures in order to improve the selectivity further are encouraged.
- Resolution GFCM/31/2007/3 – through this resolution GFCM Members agreed on voluntary implementation of at least the 40 mm square mesh codend in bottom trawling.
- REC-GFCM/31/2007/1 on the mesh size of trawlnets exploiting demersal resources – Members may continue authorizing, until 31 May 2010 only, the use of codend mesh size smaller than 40 mm to operate in certain local and seasonal

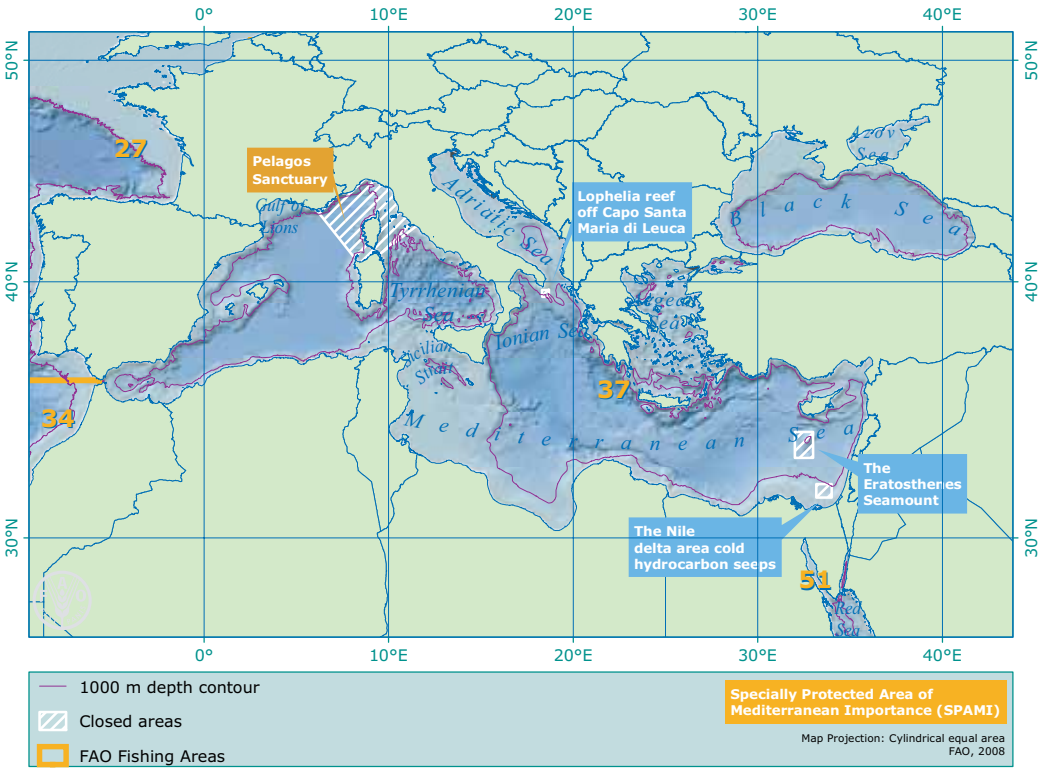
demersal trawl fisheries exploiting not-shared demersal stocks. However, this derogation applies only to fishing activities already formally authorized by the GFCM Members and shall not involve any future increase in fishing effort provided.

In addition, a recommendation on the management of fishing effort on demersal species (GFCM/2006/1) has been adopted, requiring GFCM to develop a management programme of the fishing effort concerning, in particular, demersal trawl fisheries exploiting, among others, European hake, blue and red shrimp and red shrimp, in the following GSAs: Northern and Southern Alboran Sea (GSAs 1 and 3), northern Spain (GSA 6), Balearic Islands (GSA 5), Gulf of Lions (GSA 7), Corsica (GSA 8), Ligurian and North Tyrrhenian Sea (GSA 9), South and Central Tyrrhenian Sea (GSA 10), Sardinia (GSA 11), south of Sicily (GSA 16), Northern Adriatic Sea (GSA 17), Southern Adriatic Sea (GSA 18), Western Ionian Sea (GSA 19), Eastern Ionian Sea (GSA 20) and the Aegean Sea (GSA 22) (as well as in the adjacent Sub-Areas, if relevant).

A Compliance Committee, with reviewing compliance and implementation of conservation and management measures as one of its core functions, has been established (through Recommendation GFCM 2006/6). In terms of implementation of such management measures, it was resolved in a 2008 GFCM resolution (GFCM/2008/1) that Members should report annually to the Secretariat on the implementation of GFCM measures, in a standard format agreed upon in the resolution.

Vulnerable Marine Ecosystems

In protecting VMEs, REC-GFCM/30/2006/3 established three fisheries restricted areas in order to protect the deep-sea sensitive habitats. This recommendation sets out that fishing with towed dredges and bottom trawlnets shall be prohibited in the following areas: Lophelia reef off Capo Santa Maria di Leuca (to protect the deep-water coral reefs located in international waters), the Nile delta area cold hydrocarbon seeps and the Eratosthenes Seamount (see Map 3).



MAP 3
Restricted areas in the Mediterranean Sea

INFORMATION AND REPORTING GAPS

In terms of catch reporting, it has been noted that countries report their catch but no distinction is made between that taken in waters under national jurisdiction and that taken in international waters. Countries are likely to have information on where the catch was caught, but this is not necessarily included in the reporting to GFCM. Misreporting is feared to be common. Another challenge is the varying types of logbooks being used throughout the GFCM Area; this is currently being addressed through work towards establishing a standardized GFCM logbook (GFCM, 2008).

In terms of implementation of conservation measures, the Compliance Committee noted in the report of the Second Session of the Compliance Committee (Appendix I of GFCM, 2008), that a limited number of Members fulfilled the requirement to report on the status of implementation of GFCM Recommendations and Resolutions and that the lack of information undermines efforts to assess the effectiveness of GFCM measures. In the report of the Thirty-second Session of GFCM (GFCM, 2008), the lack of necessary information, particularly on fishing mortality and current fishing effort (fleet capacity, operational units), was noted. However, some rectification of this is expected to come through the adoption of the GFCM Task 1 Statistical Matrix (Resolution GFCM/2007/1), which provides a standard format for data reporting.

SOURCES OF INFORMATION

Information was gathered from various types of GFCM reports, the GFCM Authorised Vessels List, communication with GFCM staff, FAO statistical databases and scientific journals.

SUMMARY TABLE

	European hake	Blue and red shrimp[a]
Main flag states involved in fisheries in 2006	Italy, Greece, Spain, Tunisia, France and Croatia	Italy, Algeria and Spain
Estimated number of vessels of main flag states[b]	Trawlers[c]: Italy (1 748), Greece (323), Spain (802), France (117) and Croatia (151) Gillnets: Italy (8), Greece (19), Spain (19) and France (5) Set bottom longlines: Italy (90), Greece (45) and Spain (3) Not specified: Algeria (543) and Tunisia (760)	
Total reported catch by all flag states (tonnes) in 2006	32 829	6 077
Gear	Trawlers[c], gillnets and set bottom longlines	Trawlers[c]
Main fishing areas (GSAs) in 2002–2005	Italy (GSAs 17, 18, 19, 20, 21; 11), Greece (GSA 22), Spain (GSA 5) and France (GSA 7)	Italy (GSAs 19, 20, 21, 11), Algeria and Spain (GSA 5)
Status of stocks	From slight growth overexploitation to overexploited stocks	From fully exploited stocks to overexploitation
Status of bycatch species	Multispecies hake fishery – status of associated species is largely unknown	Status of discarded and associated species is unknown

[a] Could possibly include catch of giant red shrimp. Catch reported as "Aristeid shrimp nei" by Italy.
[b] As noted in the Catch and capacity summary, this does not necessarily correspond to the number of vessels actually fishing for these species.
[c] Including bottom otter trawlers, bottom beam trawlers, bottom pair trawlers, mid-water otter trawlers, mid-water pair trawlers and non-specified bottom trawlers.

ACKNOWLEDGEMENTS

The authors would like to thank Matthew Camilleri, Alain Bonzon and Federico DeRossi (GFCM) as well as Nicola Ferri (FAO) for their advice and comments on and helpful contributions to this chapter.

BIBLIOGRAPHY

Abelló, P., Bertrand, J.A., Gil de Sola, L. , Papaconstantinou, C., Relini, G. & Souplet, A. 2002. Mediterranean marine demersal resources: the MEDITS international trawl survey (1994–1999). *Scientia Marina*, 66 (Suppl. 2). Barcelona, Spain, Institut de Ciències del Mar. 280 pp.

Cacaud, P. 2005. *Fisheries laws and regulations in the Mediterranean: a comparative study.* Studies and Reviews 75. General Fisheries Commission for the Mediterranean. Rome, FAO. 40 pp.

Cartes, J.E., Maynou, F., Sardà, F., Company, J.B., Lloris, D. & Tudela, S. 2004. The Mediterranean deep-sea ecosystems: an overview of their diversity, structure, functioning and anthropogenic impacts. In *The Mediterranean deep-sea ecosystems: an overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for conservation*, pp. 9–38. Málaga, International Union for the Conservation of Nature (IUCN) and Rome, World Wide Fund for Nature (WWF).

Cau, A., Carbonell, A., Cristinafollesa, M., Mannini, A., Norrito, G., Orsi Relini, L., Politou, C.-Y., Ragonese, S. & Rinelli, P. 2002. MEDITS-based information on the deep-water red shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus* (Crustacea: Decapoda: Aristeidae). *Scientia Marina*, 66 (Suppl. 2): 103–124.

D'Onghia, G., Carlucci, R., Maiorano, P. & Panza, M. 2003. Discards from deep-water bottom trawling in the eastern-central Mediterranean Sea and effects of mesh size changes. *Journal of Northwest Atlantic Fishery Science*, 31: 245–261.

EC. 2002. Annex III of the Communication from the Commission to the Council and the European Parliament laying down a Community Action Plan for the conservation and sustainable exploitation of fisheries resources in the Mediterranean Sea under the Common Fisheries Policy. Brussels, 9 October, 2002. COM(2002)535 final.

FAO. 2003. *Report of the Sixth Session of the Scientific Advisory Committee*. Thessaloniki, Greece, 30 June–3 July. FAO Fisheries Report 714. Rome, FAO. 94 pp.

FAO. 2008. FAO Fisheries and Aquaculture Information and Statistics Service. 2008. GFCM Capture Production 1970–2005. FishStat Plus – Universal software for fishery statistical time series (online or CD-ROM). Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp

GFCM. 2008. FAO General Fisheries Commission for the Mediterranean. *Report of the Thirty-Second Session*. Rome, 25–29 February. GFCM Report 32. Rome, FAO. 85 pp.

GFCM SAC. 2006. General Fisheries Commission for the Mediterranean. *Report of the Ninth Session of the Scientific Advisory Committee (SAC)*. Rome, 24–27 October. FAO Fisheries Report 814. Rome, FAO. 106 pp.

GFCM SAC. 2007. *Report of the Transversal Workshop on Marine Protected Areas*. Salammbô, Tunisia, 24-25 May.

GFCM SAC. 2008. General Fisheries Commission for the Mediterranean. *Report of the Tenth Session of the Scientific Advisory Committee (SAC)*. Nicosia, Cyprus, 22–26 October 2007. FAO Fisheries Report 856. Rome, FAO. 144 pp.

GFCM SCSA. 2003. *Report of the Fifth Stock Assessment Sub-Committee Meeting (SCSA)*. Nicosia, Cyprus, 3–6 June.

Goñi, R., Adlerstein, S., Alvarez, F., García, M., Sánchez, P., Sbrana, M., Maynou, F. & Viva, C. 2004. Recruitment indices of European hake, *Merluccius merluccius* (Linnaeus 1758), in the Northwest Mediterranean based on landings from bottom-trawl multispecies fisheries. *ICES Journal of Marine Science*, 61: 760–773.

Kitchingman, A., Lai, S., Morato, T. & Pauly, D. 2007. How many seamounts are there and where are they located? *In* Pitcher, T.J., Morato, T., Hart, P.J.B., Clark, M.R., Haggan, N. & Santos, R.S (eds). *Seamounts: ecology, fisheries and conservation*. Oxford, United Kingdom, Blackwell. 527 pp.

Orsi Relini, L., Papaconstantinou, C., Jukic-Peladic, S., Souplet, A., Gil De Sola, L., Piccinetti, C., Kavadas, S. & Rossi, M. 2002. Distribution of the Mediterranean hake populations (*Merluccius merluccius smiridus* Rafinesque, 1810) (Osteichthyes: Gadiformes) based on six years monitoring by trawl surveys: some implications for management. *Scientia Marina*, 66 (Suppl. 2): 21–38.

Papanicolopulu, I. 2007. A note on maritime delimitation in a multizonal context: the case of the Mediterranean. *Ocean Development & International Law*, 38: 381–398.

Politou, C.-Y., Kavadas, S., Mytilineou, C.H., Tursi, A., Carlucci, R. & Lembo, G. 2003. Fisheries resources in the deep waters of the eastern Mediterranean (Greek Ionian Sea). *Journal of Northwest Atlantic Fishery Science*, 31: 35–46.

Sardà, F., Calafat, A., Flexas, M.M., Tselepides, A., Canals, M., Espino, M. & Tursi, A. 2004. An introduction to Mediterranean deep-sea biology. *Scientia Marina*, 68 (Suppl. 3): 7–38.

Schembri, P.J., Dimech, M., Camilleri, M. & Page, R. 2007. Living deep-water *Lophelia* and *Madrepora* corals in Maltese waters (Strait of Sicily, Mediterranean Sea). *Cahiers de Biologie Marine*, 48: 77–83.

Tudela, S., Simard, F., Skinner, J. & Guglielmi, P. 2004. The Mediterranean deep-sea ecosystems: a proposal for their conservation. In: *The Mediterranean deep-sea ecosystems: an overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for conservation*, pp. 39-47. Málaga, International Union for the Conservation of Nature (IUCN) and Rome, World Wide Fund for Nature (WWF).