Volunteers in Marine Conservation Monitoring: a Study of the Distribution of Seahorses Carried Out in Collaboration with Recreational Scuba Divers

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Abstract: *Seahorses (*Hippocampus*) live in tropical and temperate waters. Habitat degradation and fishery overexploitation have led to drastic population declines on a global scale. Population monitoring is therefore essential to determine current status and manage conservation. In this first study in Italian waters on the geographic and ecological distribution of the two Mediterranean species,* Hippocampus hippocampus *and* Hippocampus ramulosus*, recreational scuba divers were recruited and trained to report sightings. A specially formulated questionnaire was produced and distributed to scuba diving schools and centers. In the 3-year study, 2536 divers spent 6077 diving hours gathering data and completed 8827 questionnaires. Eight percent of the questionnaires showed seahorse sightings, for a total of 3061 sighted specimens, 68% of which referred to* Hippocampus ramulosus. *The two species had overlapping geographic distributions. Seahorse abundance varied, with the northern Adriatic Sea showing greatest abundance, followed by the central-southern Tyrrhenian Sea. Seahorses were rare in the Ligurian and northern Tyrrhenian seas. Preferred habitats were shallow areas with either sandy bottoms or* Posidonia oceanica *(L.) Delile meadows. Seahorse distribution may be correlated with the degree of degradation of* P. oceanica *meadows. Resource users (the divers) were willing to take part in biological monitoring and contributed in scientific terms by collecting considerable amounts of data over short time periods and in economic terms by decreasing costs. The greatest limitation with volunteers was the difficulty in obtaining a uniformly distributed sample across time and space. We conclude that recreational divers and other resource users can play an active part in monitoring the marine environment and that the Mediterranean* Hippocampus *Mission may be used as a model for biodiversity monitoring.*

Key Words: *Hippocampus* monitoring, Mediterranean *Hippocampus* Mission, scuba, seahorse monitoring, volunteers in research

Voluntarios en el Monitoreo de Conservación Marina: un Estudio de Distribución de Caballitos de Mar Llevado a Cabo con Buzos Scuba Recreativos

Resumen: *Los caballitos de mar (*Hippocampus*) viven en aguas tropicales y templadas. La degradación del hábitat y la sobreexplotación pesquera han conducido a declinaciones poblacionales drásticas en una escala global. Por lo tanto, el monitoreo de poblaciones es esencial para determinar el estatus actual y gestionar su conservación. En este primer estudio en aguas italianas sobre la distribución geográfica y ecológica de dos especies Mediterráneas,* Hippocampus hippocampus *e* Hippocampus ramulosus*, se reclutó y entrenó a buzos scuba recreativos para reportar avistamientos. Un cuestionario especialmente formulado fue producido y distribuido en escuelas y centros de buceo scuba. En el estudio de 3 años, 2536 buzos pasaron 6077 horas reuniendo datos y completaron 8827 cuestionarios. Ocho por ciento de los cuestionarios mostraban avistamientos de caballitos de mar, para un total de 3061 individuos avistados, de los cuales 68% se referían a* Hippocampus ramulosus. *Las dos especies tuvieron distribuciones geográficas traslapadas. La abundancia de caballitos de mar varió, el Mar Adriático norte mostró la mayor abundancia seguido por el centro-sur del Mar Tirreno. Los caballitos*

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de mar fueron raros en en los Mares de Ligurian y norte del Tirreno. Los hábitats preferidos fueron áreas someras con fondo arenoso o con praderas de Posidonia oceanica *(L.) Delile. La distribución de caballitos de mar puede correlacionarse con el nivel de degradación de las praderas de* P. oceanica*. Usuarios del recurso (los buzos) estuvieron dispuestos a participar en el monitoreo biológico y contribuyeron en términos científicos al colectar cantidades considerables de datos en períodos de tiempo cortos y en términos económicos al reducir los costos. La mayor limitación con los voluntarios fue la dificultad para obtener una muestra distribuida uniformemente en el tiempo y espacio. Concluimos que los buzos recreativos y otros usuarios del recurso pueden jugar un papel activo en el monitoreo del ambiente marino y que la Misión* Hippocampus Mediterránea *puede ser utilzada como un modelo para el monitoreo de biodiversidad.*

Palabras Clave: Misión *Hippocampus* Mediterránea, monitoreo de caballitos de mar, monitoreo de *Hippocampus*, scuba, voluntarios en investigación

Introduction

Seahorses (*Hippocampus*, Syngnathidae, Syngnathiformes) have an evolutionary history dating back at least 40 million years. Thirty-two species are distributed throughout tropical and temperate regions (Lourie et al. 1999). Their habitats include coral reefs, mangroves and seagrass meadows. Maximum adult size varies between 10 and 300 mm according to species. It is the life-history traits of seahorses—low reproductive rate, monogamy, sedentary behavior, and fragmented distributions—that enhance the vulnerability of these creatures (Vincent 1994*a*, 1994*b*, 1995; Kvarnemo et al. 2000).

Seahorses have been featured in myths and legends since ancient times and are still used as ingredients in traditional medicines (supposedly healing respiratory problems and male impotence), especially in Southeast Asia and China (Vincent 1995, 1996). They are also fished for the aquarium and curio trades. In some areas seahorse populations have been reduced by 50% over a 5-year period (Vincent 1995, 1996; Lockyear et al. 1997). Their decline is also associated with habitat degradation caused by marine dredging, waste dumping, chemical pollution, and land reclamation (Vincent 1995). Around the mid-1990s, widespread decline of *Hippocampus* populations was brought to the attention of the international community, leading to their classification as threatened species, inclusion in the World Conservation Union Red List of Threatened Species (Vincent & Hall 1996; World Conservation Union 2002) and, in 2002, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2002). This strengthened the case for the need to monitor and sustainably manage seahorse populations.

In 1999 the Biology Department of the University of Bologna began work on a 3-year research project called Mediterranean *Hippocampus* Mission to (1) test the effectiveness of volunteers for monitoring marine environments to save time and money and (2) collect data on the distribution of the two Mediterranean seahorse species, *H. hippocampus* and *H. ramulosus* (= *H. guttulatus*). Requirements for volunteers included an interest in marine conservation consistent with the objectives of the project, a willingness to raise project awareness and be trained to suit the project's needs, and scuba qualifications.

Recreational scuba diving is an increasingly popular sport worldwide. The Recreational Scuba Training Council (RSTC 1997) estimates that there are 6 million certified European divers, 330,000 of which are in Italy. Importantly, the overwhelming majority of divers do not, as it is still widely thought, dive to hunt or collect marine organisms; instead, they observe and take photographs or videos of marine life. Most certified divers subsequently use facilities and services of accredited diving centers, which provide experienced dive guides and instructors who typically brief divers on important aspects of dives such as depth, duration, and safety and on the plant and animal life they might encounter.

Given the above, recreational scuba diving could be considered an activity with minimal impacts on the environment (Tilmant 1987). Studies have shown, however, that scuba divers can have negative impacts on marine environments through direct physical contact and stirring of sediments (Hawkins & Roberts 1992; Medio et al. 1997; Zakai & Chadwick-Furman 2002). Potential environmental impacts are therefore an important consideration in marine areas that attract significant tourism. However, scuba diving, as an important part of local economies, also provides a strong incentive for conservation efforts (Dixon et al. 1993; Medio 1996; Hawkins et al. 1999; Tratalos & Austin 2001). The importance of educating divers in environmental awareness is evident (Brylske 2002), especially to limit impacts while still supporting local economies (Medio et al. 1997; Tratalos & Austin 2001). Medio et al. (1997), for example, showed that environmental awareness programs and tools such as pre-dive briefings can positively influence divers' behavior, reducing both the rate and type of impact to coral reefs and other marine habitats.

Increasing environmental awareness goes beyond theorizing or regulatory actions and should extend to the practical involvement of the general public in conservation efforts. By participating in environmental projects, individuals have the opportunity to contribute to the environmental cause in a practical way (Newman et al. 2003; Pattengill-Semmens & Semmens 2003). Mediterranean *Hippocampus* Mission offered Italian recreational divers precisely this opportunity: participation in the first study on the geographical and ecological distribution of seahorses in the Mediterranean.

Methods

The mission began in 1999 and lasted to the end of 2001. After each dive the recreational divers reported the distribution of seahorses they saw on a specially formulated questionnaire (Fig. 1; for other marine conservation monitoring programs involving recreational divers, see Schmitt & Sullivan 1996; Pattengill-Semmens & Semmnes 2003). To maximize the number of volunteers, we contacted two of the largest educational scuba diving agencies in Italy: Scuba Schools International and Scuba Nitrox Safety International. These agencies produced the questionnaires and distributed them to diving schools and swimming pools where divers undertook instruction, diving centers, and dive shops. The educational scuba diving agencies, in collaboration with the university, also organized thematic workshops for instructors, divemasters, and private divers to train them in the required research methods so they could instruct other volunteers at the dive sites. The workshops, called *Hippocampus* Day, took place over weekends at various tourist localities and at the annual European Eu.Di. scuba diving show in Italy and included general ecological awareness and environmental education as well as conservation of marine biodiversity. These workshops were a time- and cost-effective method for volunteer training (Newman et al. 2003). In a relatively brief period of time, a considerable number of motivated volunteers were trained in the collection of data and in the recruitment of other divers. The environmental association Underwater Life Project also contributed to the recruitment and training of volunteer scuba divers by asking its own staff to participate. During the project, the University of Bologna's Press Office contacted the media, resulting in the dissemination of information regarding the project through regional and national television, radio and newspapers. The project's aims and methods were reported and recreational divers were invited to participate in data collection. The efficiency of our volunteer recruitment training program was estimated to be between 8.5% and 10.1% (in 3 years, of the 25,000–30,000 divers committed to the program, 2536 filled out questionnaires). The project had the patronage of the Italian Ministry of the Environment.

Recorded information included the diver's name, address, and dive site (site, date, depth, time) and details of seahorse sightings (depth, habitat, number of individuals sighted, species). Seahorse species were identified based on the presence (*Hippocampus ramulosus*) or absence (*H. hippocampus*) of dorsal dermal flaps (Figs. 1 & 2), a distinguishing trait between the two species (Whitehead et al. 1986; Riedl 1991; Garrick-Maidment 1998). If uncertain, divers recorded *Hippocampus* spp.

Completed questionnaires were sent to Underwater Life Project headquarters, where a database for project results had been set up. These data were sent to the Department of Biology of the University of Bologna twice yearly, checked, and processed, and reports were prepared with an update on the project and its main results. The reports were mailed to divers who had contributed the most questionnaires. This direct feedback from the university to divers was a way of thanking them for their contribution to the project, probably enhancing their commitment to the study (as was the case in other monitoring programs; Newman et al. 2003; Pattengill-Semmens & Semmens 2003).

To sustain the project, the Department of Evolutionary and Experimental Biology supplied both a fellow, who committed anywhere from 2200 to 2500 hours to the program over the 3-year period, and a graduate student. The diving agency Scuba Schools International Italy granted the department US$55,000 over the 3-year period. This sum paid for the fellowship, computer hardware, software, and participation at conservation conferences and workshops related to the project. The diving agency also invested US$25,000 to pay for printing costs and general publicity (posters, stickers, video cassettes, and page spreads in newspapers and popular magazines).

Results

Number of Sightings

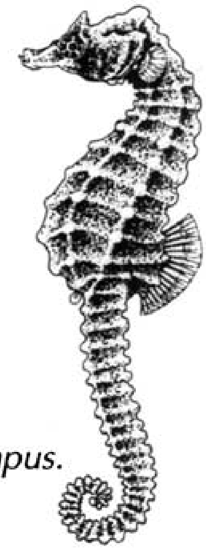
During the 3-year study, 2536 volunteers dove for 6077 hours and completed 8827 questionnaires (Table 1). Completed questionnaires varied from 1 per diver to as many as 140. Eight percent of questionnaires reported seahorse sightings, for a total of 3061 observed individuals. Sighting frequency was 0.504 (SE = 0.034) seahorses per diving hour (Table 1). The majority of sightings (68.4%) were of *Hippocampus ramulosus* individuals. During the period of study, the frequency of seahorse sightings varied significantly (one-way analysis of variance, $p = 0.003$). In particular, seahorse sightings were less frequent during the second year of observation (0.357, SE = 0.053) than during the first (1.235, SE = 0.093; Scheffé's test, $p < 0.05$), whereas sightings during the second and third years did not differ (Scheffé's test, $p > 0.05$).

University of Bologna
Department of Biology

Italian Ministry of the Environment

Name	Address
Surname	Diving License (educational agency and level)

Diving point	
Closest populated area	
Province	
School-Diving Center	
Date of the dive	
Maximum depth	
Actual bottom time	
Time the dive began	



Watch out for my "mane"! I am *Hippocampus ramulosus*.

I don't have a " mane"! I am *Hippocampus hippocampus*.

YES **DID YOU SEE ANY SEAHORSES?** **NO**

YES

Congratulations! Please answer the following questions:

At which depth were they sighted?	
In which habitat? (Only one answer) ☐ meadow of *Posidonia* ☐ sandy bottom ☐ rocky bottom ☐ wall ☐ other	
How many minutes did you spend in this habitat?	
How many seahorses did you see? (number)	

Did the seahorses have a "mane"?

- ☐ YES (you saw Hippocampus ramulosus)
- ☐ NO (you saw Hippocampus hippocampus)
- ☐ I DON'T KNOW (you saw Hippocampus)

NO

Better luck next time! Please answer the following questions:

At which depth did you spend most of your dive?	
In which habitat did you spend most of your dive? (only one answer) ☐ meadow of *Posidonia* ☐ sandy bottom ☐ rocky bottom ☐ wall ☐ other	
How many minutes did you spend in this habitat?	

Thank you for your cooperation, you have helped us take the first step towards saving the seahorse.
The results of our study will soon be published.

Please send this questionnaire to:

SSI Scuba Schools International
via Bergami 4, I-40133 Bologna, Italy
Tel. +39-051-383082
Fax +39-051-383554

Marine Science Research Group

SSI Scuba Schools International

SNSI Scuba Nitrox Safety International

Figure 1. Questionnaire distributed to diving schools, swimming pools where divers undertook instruction, diving centers, and dive shops. Volunteer divers completed the questionnaire after each dive regardless of whether or not they had sighted seahorses.

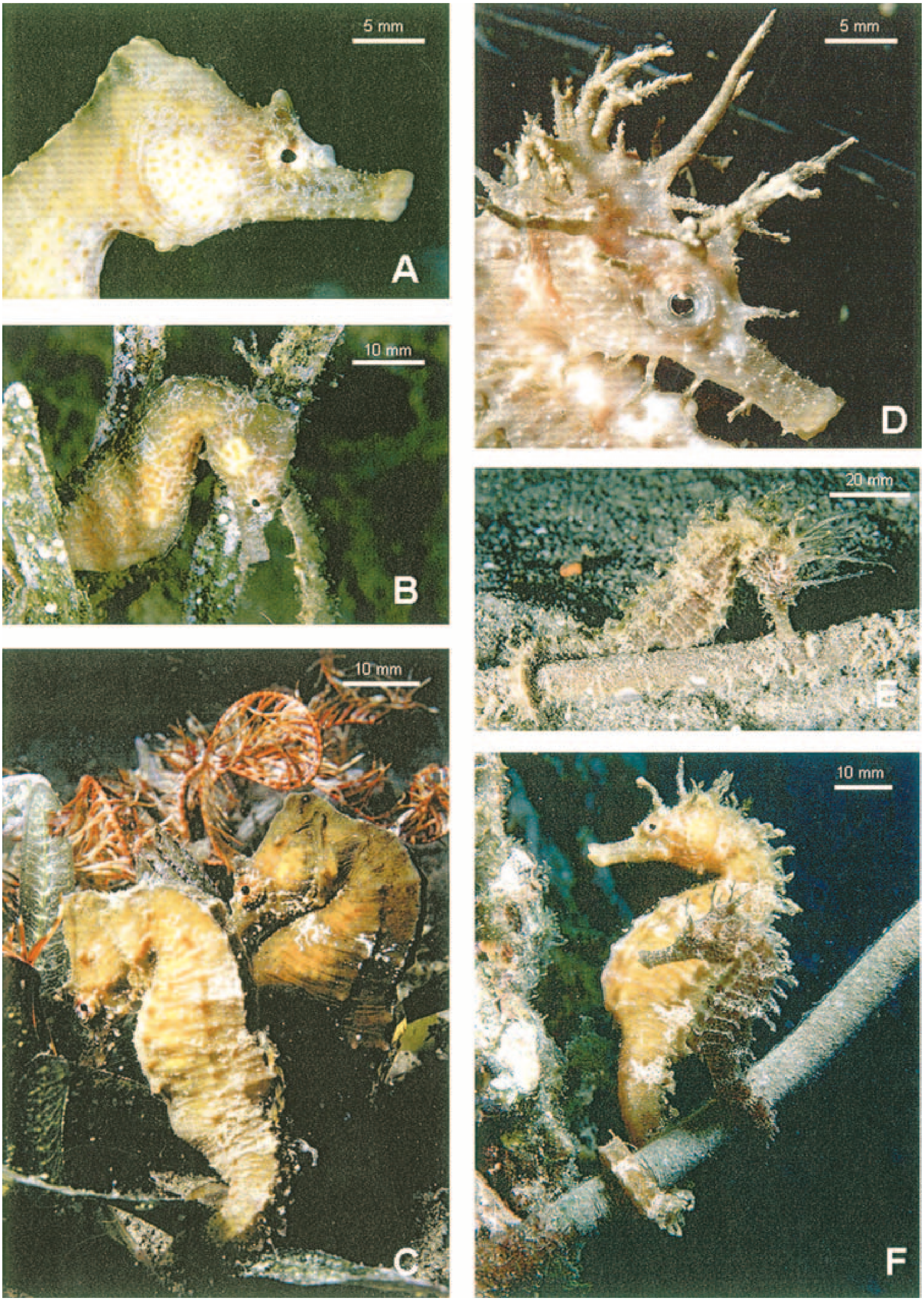

5 mm
A
10 mm
B
10 mm
C
5 mm
D
20 mm
E
10 mm
F

Table 1. Data collected by volunteer divers during the 3-year survey project on *Hippocampus*.*

Year	*No. questionnaires*	*Diving hours*	*Questionnaires reporting* Hippocampus *(%)*	Hippocampus hippocampus	Hippocampus ramulosus	Hippocampus *spp.*	*Total*
1999	1813	1320	20.79	0.393 (0.064)	0.677 (0.060)	0.165 (0.039)	1.235 (0.093)
2000	3139	2098	6.56	0.014 (0.004)	0.317 (0.052)	0.025 (0.008)	0.357 (0.053)
2001	3875	2659	4.03	0.028 (0.006)	0.201 (0.044)	0.027 (0.013)	0.257 (0.046)
All three years	8827	6077	8.37	0.103 (0.014)	0.344 (0.029)	0.056 (0.011)	0.504 (0.034)

**Frequency of seahorse sightings is number of individuals per diving hour. Standard errors are given in parentheses.*

Geographic Distribution

The areas surveyed included parts of the Ligurian, Tyrrhenian, and Adriatic seas off 18 coastal regions (Fig. 3). The regions on the Ligurian and Tyrrhenian seas included the islands of Corse, Sardegna, and Sicilia, and the mainland regions of Provence in France and the regions of Liguria, Toscana, Lazio, Campania, Basilicata, and Calabria in Italy. The Adriatic coastal regions were Puglia, Molise, Abruzzo, Marche, Emilia-Romagna, Veneto, and Friuli–Venezia Giulia in Italy and Istra in Croatia.

Data collected by recreational divers was not homogeneously distributed across regions (Fig. 4a & 4b). More questionnaires were collected for the Ligurian and Tyrrhenian coasts (86%) than for the Adriatic (14%). The most questionnaires (71%) were collected for Toscana and Liguria, whereas no questionnaires were collected for Basilicata and Abruzzo.

There was no correlation between the number of seahorses sighted and the number of diving hours performed by region over the 3-year period ($r = 0.032, p > 0.05$; Fig. 4b & 4c). There were high numbers of sightings in some regions with only moderate survey effort (number of diving hours). Two examples of this were Friuli–Venezia Giulia, where just 2.5% of the total survey effort yielded 39.0% of all seahorse sightings, and Campania, where similarly low effort (3.2%) yielded 18.3% of individuals sighted (Fig. 4b & 4c).

Given the geographic heterogeneity in survey effort, the abundance of seahorses per region was expressed as the mean number of individuals sighted per diving hour (Fig. 5). The highest frequency of sightings was reported off the coasts of Friuli–Venezia Giulia (7.808, SE = 0.926) and Veneto (5.654, SE = 1.575), on the northern Adriatic Sea, followed by the central and southern Tyrrhenian Sea, off the coasts of Campania (2.197, SE = 0.395), Calabria (1.571, SE = 0.206), and Sardegna (1.356, SE = 0.148) (Fig. 5a). Data from Provence (0.000, SE = 0.000), Liguria (0.119, SE = 0.019), Corse (0.000, SE = 0.000), and Toscana (0.076, SE = 0.011) revealed low frequencies of sightings in the Ligurian and northern Tyrrhenian Seas. The geographic distribution of the two seahorse species was generally overlapping except in areas with the highest frequency of sightings (i.e., the Friuli–Venezia Giulia coast had the highest abundance of *H. ramulosus* [6.745, SE = 0.194] and the Veneto coast had the highest abundance of *H. hippocampus* [2.737, SE = 1.234]). The former species was also significantly well represented off the Sardegna coast (1.297, SE = 0.147), whereas there were few sightings of *H. hippocampus* in this area (0.027, SE = 0.020) (Fig. 5b & 5c).

Habitat Distribution

The distribution of survey effort by habitats was not homogeneous: most dives took place in habitats with pebbly-rocky seabeds and vertical walls (69% of questionnaires reported dives in these two habitats; Table 2). There was no correlation between the number of individuals sighted and the number of diving hours by habitat ($r = 0.245, p > 0.05$). The number of sightings was low in habitats where the most diving hours were spent. In

Figure 2. Some morphological and ecological aspects of the two Mediterranean seahorse species, Hippocampus hippocampus *(a–c) and* Hippocampus ramulosus *(d–f). (a) Close-up of the head of* H. hippocampus*. The snout is relatively short; note the absence of dermal flaps.* (*b*) A *H. hippocampus* hidden among seagrass leaves. (*c*) Two *H. hippocampus* partially hidden by seagrass leaves. Note the tail of one of the individuals wrapped around a leaf. Also note the arms of a sea lily (Crinoidea, *Antedon mediterranea*) in the background. (*d*) Close-up of the head of *H. ramulosus*. Its snout is relatively long; also note the presence of dermal flaps. (*e*) An individual of *H. ramulosus* on a sandy bottom. Its tail is wrapped around a small wood branch. (*f*) Two individuals of the species *H. ramulosus* cling to the tube of a polychaete worm (*Sabella spallanzanii*)

Figure 3. Eighteen coastal regions of the Ligurian, Tyrrhenian, and Adriatic Seas.

contrast, sandy-bottomed areas, although accounting for only 12.4% of the total diving effort, had the highest number of seahorse sightings (49.2% of sightings over the course of 3 years).

The preferred habitats of seahorses are areas with sandy bottoms and meadows of *Posidonia oceanica* (L.) Delile (frequency of sightings can be found in Table 2). Although the frequency of *H. hippocampus* sightings appeared relatively high in both these environments, *H. ramulosus* showed a marked preference for habitats with sandy bottoms.

Bathymetric Distribution

The distribution of survey effort across the four depth bands (1–10, 11–20, 21–30, 31–40 m) appeared to be unimodal. Divers spent the most time (57.0% of the total diving effort) between the depths of 11 and 20 m. There was no correlation between the number of diving hours and the number of seahorses sighted by depth ($r = 0.578$, $p > 0.05$). Seahorse abundance decreased exponentially with increasing depth. The equation matching depth to abundance of seahorses was $y = 10.498x^{-1.228}$, where y is number of total *Hippocampus* per diving hour, x is depth (m) ($r = 0.997$, $p < 0.01$; total data [i.e., 1999 + 2000 + 2001, were used to calculate the coefficients]).

Discussion

Use of Volunteers for Environmental Monitoring

Volunteers and amateurs have contributed to scientific knowledge for centuries. Some scientific fields such as astronomy and ornithology have always encouraged volunteers to collect data (Root & Alpert 1994; Mims 1999). Only recently have international academic and scientific communities become aware of the contribution that can be made by volunteers in environmental monitoring. For example, a U.S. intergovernmental task force of experts found that more than 500 volunteer groups in the United States are involved in monitoring water quality and recommended that the efforts of these groups be integrated into government programs (U.S. Geological Survey 1995). Furthermore, the U.S. Environmental Protection Agency (EPA) supports surveillance performed by volunteers by sponsoring conferences to promote the exchange of information among volunteer groups, governmental agencies, industry, and educators and by granting funds for the training of volunteers and for financing data collection (EPA 1997). During the 1990s, the explosion of interest in scuba diving (RSTC 1997) led several programs in marine environmental monitoring to include volunteer divers (Fish Survey Project, Florida and Caribbean Sea, http://www.reef.org; Reef Check, global, http://www.reefcheck.org; Reef Watch, South Australia, http://www.reefwatch.asn.au; Project Seahorse, Philippines, http://www.seahorse.fisheries.ubc.ca; Mediterranean *Hippocampus* Mission, Mediterranean Sea, http://www.marinesciencegroup.org).

It seems evident that volunteers could be used to collect data that are intrinsically difficult to obtain and thus could fill holes in our knowledge in such areas. Difficulties arise, however, when administrators and researchers must guarantee the quality and validity of the data collected by volunteers. Results of some studies have shown that under conditions of appropriate recruitment and training, volunteer-collected data are qualitatively equivalent to those collected by professionals (Greenwood 1994; Schmitt & Sullivan 1996; Fore et al. 2001; Newman et al. 2003; Pattengill-Semmens & Semmens 2003). A number of features in our study lead us to conclude that the volunteer-collected data presented here are reliable. (1) Volunteers were assisted during data collection in the field by dive guides and instructors who had previously attended workshops and received training on project objectives and methodology. (2) Seahorse identification was not difficult because there are clear morphological differences between the two species. (3) Information requested on the questionnaire such as dive location, depth, dive time, and habitat are details most divers routinely record in their personal divelogs, whether the purpose of the dive is recreation or data collection. (4) Finally, data were markedly consistent across years, indicating a strong degree of reliability. Because no professional surveys of seahorse abundance and distribution could be found in the literature, however, no data were available with which to compare our results, so reliability cannot be quantitatively assessed.

The participation of volunteer scuba divers in the Mediterranean *Hippocampus* Mission exceeded our expectations. We calculated that it would have taken a professional researcher 20 years and would have cost more

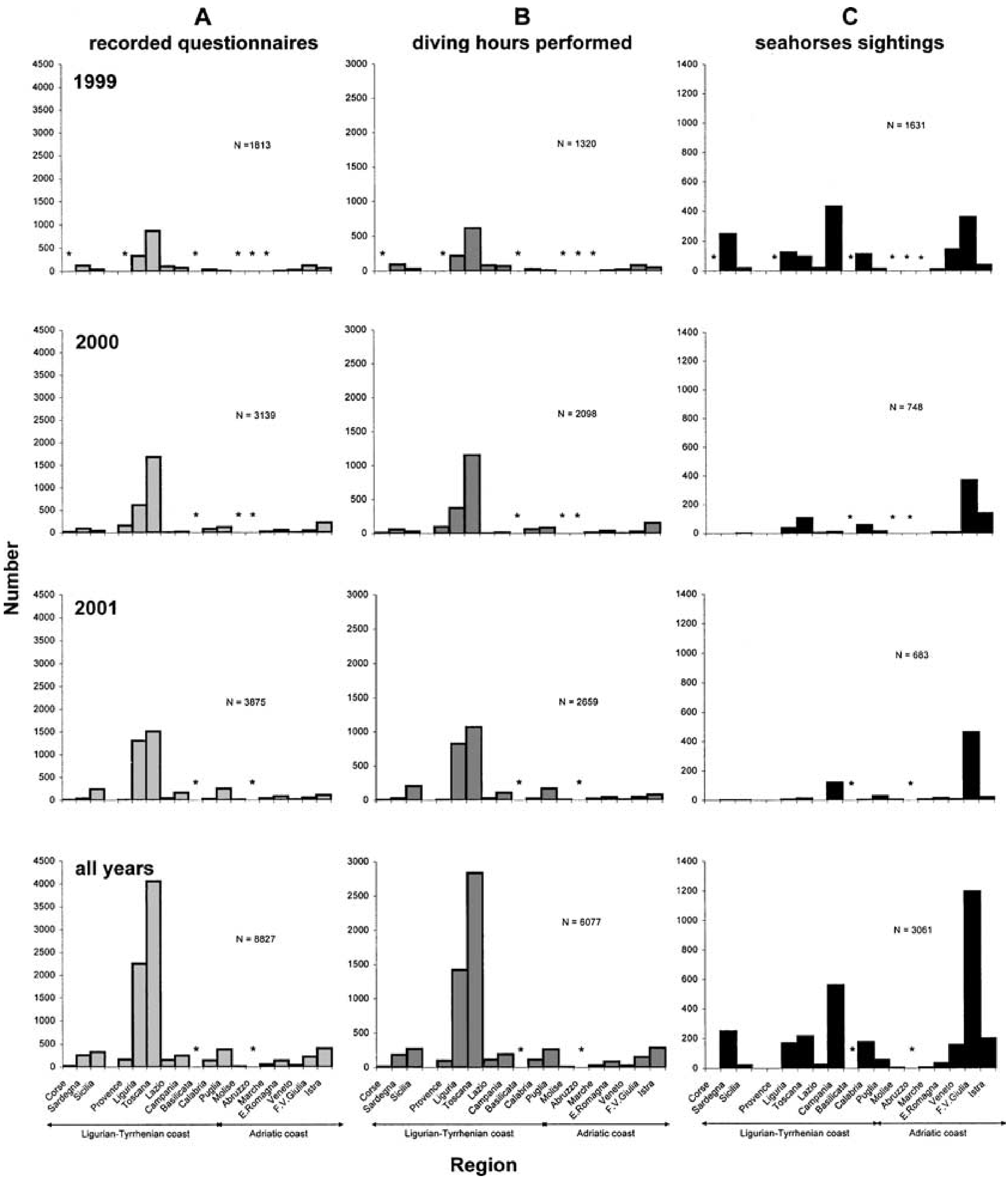


Figure 4. Number of (a) questionnaires collected, (b) diving hours performed, and (c) seahorses sighted per region over the 3-year study of Hippocampus. *Horizontal arrows at the bottom of the graphs indicate whether the regions border the Ligurian-Tyrrhenian or Adriatic seas. Asterisk indicates that no questionnaires were collected.*

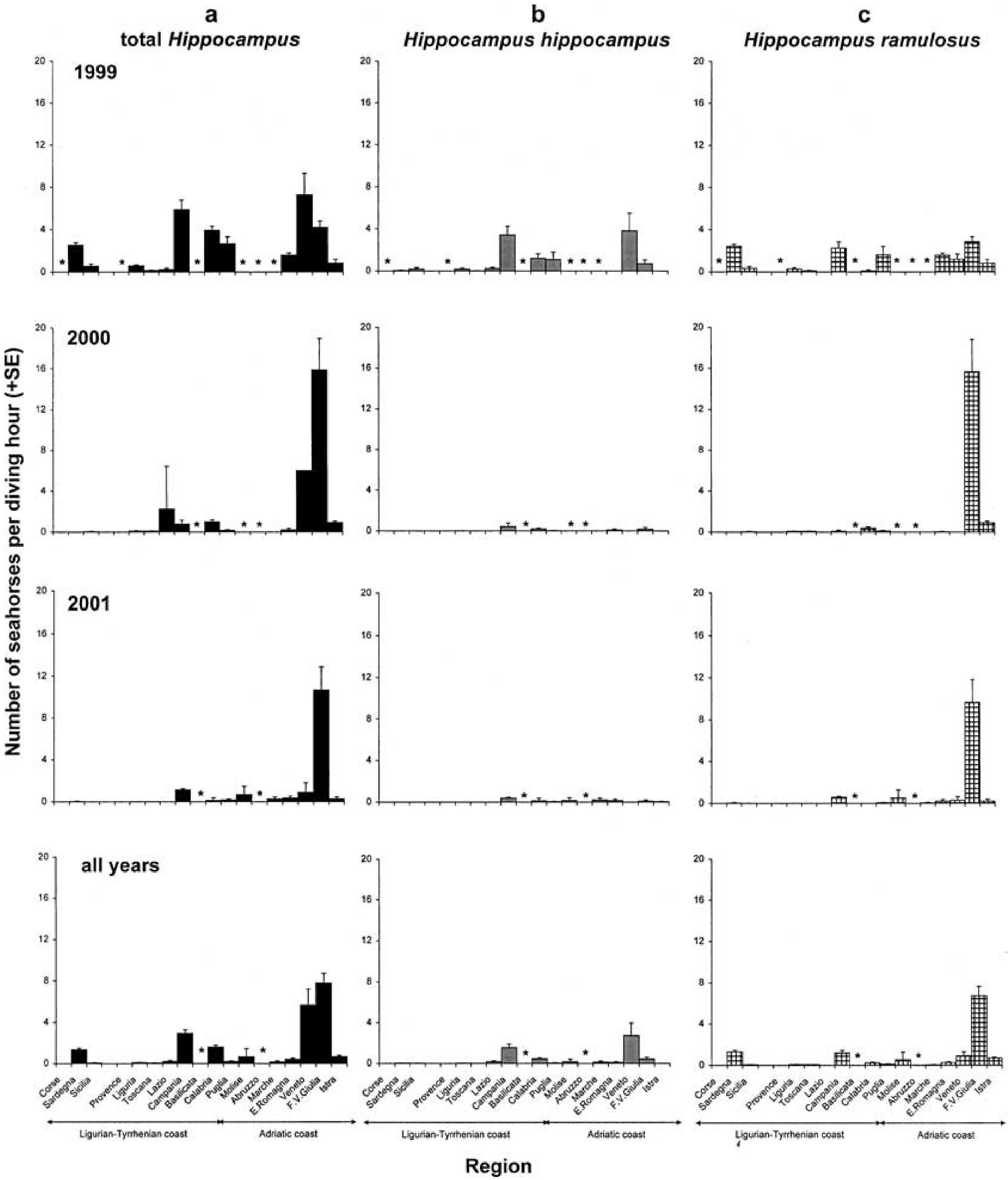


Figure 5. Frequency of seahorse sightings per region over the 3-year period of study. Horizontal arrows at the bottom of the graphs indicate whether the regions border the Ligurian-Tyrrhenian or Adriatic seas. Asterisk indicates that no questionnaires were recorded.

Table 2. Habitat distribution based on the total number (i.e., 1999 + 2000 + 2001) of questionnaires, diving hours, number of seahorses sighted, and frequency of seahorse sightings.*

Habitat	*Questionnaires*	*Diving hours*	*Seahorses sighted*	Hippocampus hippocampus	Hippocampus ramulosus	*Total* Hippocampus
All three years (1999, 2000, 2001)	8827	6077	3061	0.103 (0.014)	0.344 (0.029)	0.504 (0.034)
Posidonia oceanica meadow	1187	844	460	0.327 (0.084)	0.191 (0.038)	0.546 (0.092)
Sandy bottom	1131	751	1505	0.191 (0.045)	1.557 (0.213)	2.004 (0.226)
Pebbly-rocky bottom	3347	2340	552	0.052 (0.014)	0.150 (0.021)	0.236 (0.027)
Wall	2726	1858	472	0.038 (0.009)	0.192 (0.021)	0.254 (0.024)
Other	226	141	34	0.021 (0.025)	0.222 (0.080)	0.243 (0.083)
Not specified	210	144	38	0.062 (0.031)	0.166 (0.050)	0.263 (0.062)

**Frequency is the number of individuals per diving hour. Standard errors are given in parentheses.*

than US$1,365,000 to collect the same amount of data our volunteers collected in just 3 years. This is further evidence that (1) the public at large wants to take part in biological monitoring, and there is considerable potential for people practicing other recreational activities to be recruited by the scientific community to assist with environmental monitoring programs and (2) volunteers can collect a considerable amount of information over a relatively short amount of time and save the public and scientific community precious financial resources because they directly incur part of the costs needed for research projects (see also the recently published results of other monitoring projects involving volunteers, such as Newman et al. [2003] for terrestrial environments and Pattengill-Semmens and Semmens [2003] for marine environments).

A major limitation in the recruitment of volunteers for this kind of work is the absence of guarantees that the data set they acquire will be uniformly distributed across time and space. Clearly, the distribution of survey effort was not homogeneous across regions, depths, or habitats. But because recreational divers reported from most regions, habitats, and depths during each year of the study, it can be considered adequate for our purposes. In particular, with regard to the geographic distribution of the survey effort, and notwithstanding the lack of homogeneity, 13 of the 15 Italian coastal regions were surveyed (Basilicata and Abruzzo being the exceptions), as were three regions bordering Italy, Corse, Provence, and Istra. There are several reasons for the more significant diving effort along the Liguria and Toscana coasts. A behavioral reason is that recreational divers dive for pleasure and so choose stretches of coastline that are more enjoyable (the waters of the Ligurian and Tyrrhenian Seas are more limpid than the Adriatic). Logistically, there is a high density of diving centers along the Ligurian and northern Tyrrhenian coasts (21.4 diving centers/100 km of coastline vs. a national average of 6.7; data from http://www.diveitaly.com). Politically, Italy's national diving agencies supporting the project are located in the north, as are most of their affiliated diving schools, because of the diving quality and logistics, and divers from northern Italy prefer the Liguria and Toscana coasts. The following actions were taken to increase the homogeneity of the distribution of diving effort. First, incentives were granted to divers who dove in less popular areas; for example, we listed their names on the project's Web site and in our periodic reports on works in progress, thank-you letters were sent to individual divers, prizes were granted by our partners including subscriptions to recreational scuba diving and travel magazines, popular scientific journals, and all-expense paid diving trips (these kinds of incentives have been used in other environmental monitoring programs such as the Fish Survey Project, http://www.reef.org). Second, the university, in collaboration with the diving centers and tourist agencies located in the less-popular diving areas, endorsed the organization of promotional campaigns to inform local governments, the coast guard, tourist information bureaus, and local and national newspapers and television about the project. As part of the campaign, divers taking part in the training workshops were given discounts on room and board and diving costs. Our own experience and that of Brylske (2002) shows that these types of incentives greatly improve communication between the tourism community and those responsible for the conservation and management of marine resources, benefiting research efforts and improving local economies.

Individual diver effort was also not evenly distributed. The number of questionnaires turned in by the individual divers ranged from 1 to 140. This substantial difference in quantity is closely related to the fundamental role that the diving schools and centers played in promoting the project. Evidently, some divers took part regularly in the activities promoted by the centers and schools, whereas others were more sporadic in their attendance. In recognition of their efforts, the diving schools and centers that were most successful in promoting the project received the Silver Seahorse, a plaque donated by the university and by the diving agencies. These centers could easily become the promoters of future environmental monitoring initiatives.

Recreational divers are the base of a complex pyramidal organization with the educational scuba diving agencies at the apex. By targeting educational diving agencies we were able to trigger a cascade effect and thereby secure the participation of thousands of people. From the experience gained during this project, we conclude that recreational scuba divers can be useful for marine environmental monitoring activities and that our project, Mediterranean *Hippocampus* Mission, may be taken as a model for monitoring marine biodiversity.

Abundance and Distribution of Seahorses along Italian Coasts

The total number of individuals observed (3061) and the frequency of sighting (0.504 individuals per diving hour) indicate a discrete presence of seahorses in Italy's coastal waters. The decrease in the frequency of sightings recorded from year 1 to year 2 could be attributable to the fact that volunteers involved in the first year were more skilled (most were professional dive masters and instructors who had attended specific training workshops) than those in the second and third years (most were newly recruited private divers). This fact supports the reduction in the frequency of sighting between the first and second year of study and the leveling out of sighting frequency between the second and third years of study.

Hippocampus ramulosus was the more abundant of the two species, with a ratio of *H. ramulosus* to *H. hippocampus* of 3.4:1.0. For British seahorse populations, Garrick-Maidment (1998) reported a significant difference in the reproduction potential of the two species, with maximum numbers of offspring per brood at 100 and 300 young for *H. hippocampus* and *H. ramulosus*, respectively. This difference in reproduction could cause the difference in abundance between the two species seen in this study. The difference could also be influenced by the greater or lesser visibility of the species. *H. ramulosus* is perhaps more easily observed by divers because of its preference for sandy-bottom habitats, where seahorses cannot easily hide. Therefore, its presence may be more accurately recorded. By contrast, *H. hippocampus*, which was also common in *Posidonia oceanica* meadows, is likely to be less easily observed by divers, a factor that may have led to underestimation of this species.

The main characteristics of habitats preferred by seahorses around Italian coasts were shallow areas with either sandy bottoms or *P. oceanica* meadows. As noted above, however, seahorses may have been underestimated in *P. oceanica* meadows, and the actual presence of seahorses in this habitat may be considerably higher than reported. Data from the literature on the habitat characteristics of Mediterranean seahorses agree with the observations made by the divers in our study (Whitehead et al. 1986; Riedl 1991; Renones & Massuti 1995; Garrick-Maidment 1998).

The greatest abundance of seahorses was reported in the northern Adriatic and central-southern Tyrrhenian seas. Seahorses are rare in the northwestern Mediterranean (Ligurian and northern Tyrrhenian seas). This distribution may be related to the degree of habitat degradation. *P. oceanica* meadows, the climax community of soft substratum infralittoral zones in the Mediterranean, have declined significantly in the Ligurian and northern Tyrrhenian seas as a result of human disturbance along the coasts (Pérès & Picard 1975; Gabrielides 1995; Marbà et al. 1996) and the introduction of an invasive tropical seaweed (Meinesz & Hesse 1991; Verlaque & Fritayre 1994; DeVillèle & Verlaque 1995). This habitat loss could explain the rarity of seahorse sightings in this area.

Implications for Conservation

To obtain a real indication of the decline of *H. hippocampus* and *H. ramulosus* and to determine whether or not they need to be protected through priority conservation interventions, it is necessary for their populations to be monitored effectively. An objective assessment of the vulnerability of Italian seahorse populations requires further studies into demographic, genetic, reproductive, behavioral and dispersive aspects of seahorse biology.

In light of the positive results of the Mediterranean *Hippocampus* Mission, we suggest that the seahorse could become a banner species for the conservation of marine biodiversity. A focus on seahorses could allow us to engage professional colleagues, policy makers, and the public in interdisciplinary conservation ventures (see also the results of Project Seahorses, http://www.seahorse.fisheries.ubc.ca). Seahorses are charismatic and regarded fondly by interest groups in diverse cultures. Seahorse conservation could hitherto be very cooperative, providing a new opportunity for constructive action toward conservation of other marine species and systems. Due to the success of the *Hippocampus* project, we have begun a new venture called Diving for the Environment: Mediterranean Underwater Biodiversity Project. In addition to monitoring seahorses, volunteer divers are also reporting the presence of 59 other taxa, including both plant and animal species (for details go to http://www.marinesciencegroup.org).

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