

Site fidelity of the dusky grouper *Epinephelus marginatus* (Lowe, 1834) studied by acoustic telemetry

Étude de la fidélité au site du mérou noir
Epinephelus marginatus (Lowe, 1834) par la télémétrie acoustique

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ABSTRACT

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Marine reserves have been established in many regions of the Mediterranean to protect threatened and vulnerable species, such as the dusky grouper, yet the value of such reserves is often uncertain because of a lack of knowledge about species' ecology and movements. We thus undertook a study to track the movements of dusky grouper over a one year period around the Island of Ustica (Sicily, Italy), where a marine reserve has been established. Two groups of dusky grouper were caught at various sites around the island and their geographical positions recorded. The first group consisted of 7 individuals (weight: 2-5.4 kg) that were released in November 1997. The second group consisted of 6 individuals (weight: 5.5-17 kg) that were released in October 1998. All fish were implanted with acoustic transmitters before being released within the core area of the marine reserve. The fish were tracked monthly (February 1998-January 1999) and daily during short periods in July-September 1998, recording depth and position. The survival and retention of the transmitters, estimated by manual tracking, was 100% in both groups. All fish homed to their site of capture (467-4,426 m) and showed strong site fidelity that persisted through the study period. The monthly displacement of the dusky grouper ranged from 20-500 m, with individuals averaging displacements from 103 m (s.d. 72 m) to 193 m (s.d. 92 m) between consecutive trackings over the study period. These were only slightly larger than those observed on a daily basis (8-197 m). The grouper were found at depths between 10 and 40 m, with the larger fish preferring deeper waters. Our results indicate that marine reserves can function in protecting the dusky grouper because of their site fidelity, but simultaneously indicate that relocating fish from surrounding areas to marine reserves is unlikely to be a successful management strategy.

RÉSUMÉ

Lembo G., I.A. Fleming, F. Økland, P. Carbonara, M.T. Spedicato, 1999 - [Étude de la fidélité au site du mérou noir *Epinephelus marginatus* (Lowe, 1834) par la télémétrie acoustique]. Mar. Life, 9 (2) : 37-43.

Des réserves marines ont été établies dans nombreuses régions de Méditerranée afin de protéger les espèces menacées et vulnérables, comme le mérou noir. Toutefois, la valeur de ces réserves pour ces espèces est souvent incertaine par manque de connaissance sur leur écologie et leurs mouvements. Ainsi, nous avons entrepris une étude pour suivre les mouvements des mérous noirs durant un an autour de l'île d'Ustica (Sicile, Italie), où une réserve marine a été établie. Deux groupes de mérous noirs ont été capturés dans des sites différents autour de l'île et leurs positions géographiques ont été enregistrées. Le premier groupe se composait de 7 spécimens (poids : 2-5,4 kg) qui ont été relâchés en novembre 1997. Le second groupe se composait de 6 spécimens (poids : 5,5-17 kg) qui ont été relâchés en octobre 1998. Tous les poissons ont été marqués avec des transmetteurs acoustiques par une intervention chirurgicale, avant d'être relâchés dans l'aire centrale de la réserve marine. Les poissons ont été suivis mensuellement (février 1998 - janvier 1999) et journalièrement pendant de brèves périodes en juillet-septembre 1998, en enregistrant leur profondeur et leur position. La survie et la rétention des transmetteurs, estimées indirectement par le «tracking» manuel, ont été de 100% pour les deux groupes. Tous les poissons sont revenus à leur site de capture (467-4 426 m) et ont montré une forte fidélité au site, qui a persisté pendant toute la période étudiée. Les déplacements mensuels des mérous noirs avaient une amplitude de 20-500 m, avec des déplacements individuels moyens variables de 103 m (écart type : 72 m) à 193 m (écart type : 92 m) entre «tracking» consécutifs pendant la période étudiée. Ces déplacements ont été seulement un peu plus importants que ceux observés sur une base journalière (8-197 m). Les mérous noirs ont été trouvés à des profondeurs de 10 à 40 m, avec les poissons les plus grands dans les eaux plus profondes. Nos résultats indiquent que les réserves marines peuvent fonctionner pour protéger les mérous noirs grâce à leur fidélité au site, mais ils indiquent également que déplacer les poissons des aires environnantes vers les réserves marines n'est probablement pas une bonne stratégie de gestion.

INTRODUCTION

Several marine reserves have been established along the Mediterranean coast during the last decade in order to protect endangered habitats and species. One of the focal species in the establishment of many of these reserves has been the dusky grouper (*Epinephelus marginatus* (Lowe, 1834)), which is a species that is particularly vulnerable to overexploitation. This vulnerability is a consequence of the species' biological characteristics, including slow growth, protogynous hermaphroditism and sexual inversion at a late age, occupation of nearshore habitats and site fidelity. As a result, the species is in general decline in many Mediterranean areas and quantitative estimates indicate that the stock is dynamically unbalanced (e.g. Kara, Derbal, 1995). Moreover, it has been included in the list of the marine organisms requiring specific management measures (Annex 3 of the Bern Convention).

The dusky grouper is considered to be a solitary species, and basically sedentary, apparently occupying a small home range (Neill, 1967). On the other hand, Chauvet *et al.* (1991) reported that the dusky grouper should not be considered strictly sedentary and there have been reports of an increase in the density of grouper in shallow rocky areas during the reproductive period (Chauvet, Francour, 1989; Zabala *et al.*, 1997). The cause of this change in density, though, remains unclear and may result from sampling biases, such as those associated with seasonal changes in activity patterns. Indeed, quantitative knowledge on the homing, site fidelity and movement dynamics of the dusky grouper during and outside the spawning season remains scarce. All of which is critical knowledge for developing successful management strategies for the species, including the use of marine reserves and the possibility of re-introductions.

We thus began a study in 1997 to track the movements of dusky grouper over a one year period around the Island of Ustica (Sicily, Italy), where a marine reserve has been established (described in Lembo *et al.*, 1999). The objective was to examine the movements, site fidelity and homing of different age/size groups of fish in relation to the marine reserve.

MATERIAL AND METHODS

After a feasibility study to investigate detection ranges of transmitter signals and codes within the research area (Lembo *et al.*, 1998), two groups of fish had acoustic transmitters surgically implanted into their body cavities, the first group in November 1997 and the second in October 1998 (table I). The fish had been caught by hook and line around the island of Ustica and the geographical coordinates and depth at the capture sites were recorded for each individual. After capture and treatment against swim bladder inflation (Spedicato, Lembo, 1996; Carbonara *et al.*, 1999), the fish were maintained in tanks with re-circulating seawater.

Two batches of acoustic transmitters were used. The first group of fish were implanted with model CAFT 16-2 transmitters, Lotek Marine Inc. (signal strength 156 dB; frequency 65.5 or 76.8 kHz; longevity 380-400 d; diameter of 1.6 cm; length 5-6.5 cm). To increase the range of detection, the second group of fish were implanted with new prototype transmitters, model CAFT 16-3, Lotek Marine Inc. (alternating between normal and enhanced pluses; signal strength 159 dB; frequency 65.5 kHz; longevity 297-408 d; switching off 6 hr daily; diameter 1.6 cm; length 8.5-10 cm). The signals for all transmitters were coded allowing individual identification. The transmitters were surgically implanted into the body cavity following the techniques of Økland *et al.* (1999).

Table I - Transmitter codes, fish characteristics, and capture, surgery and release dates of the dusky grouper belonging to the first and second groups. / Codes des transmetteurs, caractéristiques des poissons, dates de capture, dates de l'intervention chirurgicale et du lâcher des mérus noirs pour le premier et le second groupes.

	Fish code	Total length (cm)	Total weight (kg)	Capture date	Surgery date	Releasing date
Group 1	53	51.5	2.0	19.10.97	22.11.97	25.11.97
	58	51.0	2.1	08.10.97	22.11.97	25.11.97
	68	51.0	2.2	20.10.97	22.11.97	25.11.97
	70	60.0	2.9	20.10.97	23.11.97	25.11.97
	80	62.5	3.8	04.11.97	23.11.97	25.11.97
	77	66.0	4.3	05.11.97	23.11.97	25.11.97
	78	68.0	5.4	11.11.97	23.11.97	25.11.97
Group 2	166	66.5	5.5	29.10.98	30.10.98	06.11.98
	134	74.5	6.5	10.10.98	29.10.98	30.10.98
	164	72.0	8.0	29.10.98	30.10.98	06.11.98
	140	81.0	9.0	23.10.98	28.10.98	30.10.98
	144	84.5	11	14.10.98	29.10.98	30.10.98
	15	94.0	17	09.10.98	29.10.98	30.10.98

The fish were kept in the tanks for 1-7 days after surgery before being released within the core zone of the marine reserve at Ustica. They were then manually tracked (detailed in Lembo *et al.*, 1999) a few days thereafter and subsequently, monthly or bimonthly (from February 1998 to January 1999). In addition, during the spawning season (from July to September) they were tracked daily for short periods (2-3 consecutive days). Once located, the depth and position of the fish were recorded using an ecosounder and a Geographical Positioning System (GPS), respectively. The precision of the GPS was 10 m.

RESULTS

Scuba observations during release showed that the fish descended immediately to the bottom and most entered caves or settled in crevices. Only the largest dusky grouper was observed swimming along the bottom and away from the release site. Two days after release the seven dusky grouper belonging to the first group (table I) were still found within the release area (i.e. core of the marine reserve), but by the next tracking, a month later, they had dispersed. Thereafter (February), the search area for tracking was extended to the catch sites, where each grouper was detected. More frequent trackings of the second group of dusky grouper (table I) showed that they returned to their sites of capture within 3-6 days. Thus, all fish from both release groups, independent of the length of time in captivity (1-7 wks; table I), homed to their sites of capture that ranged between 467-4,426 m from the site of release (figure 1). The fish were found 128 m

Table II - Distance moved (in meters) between successive trackings (two or more) conducted within 2 days (3-28 hours apart). Number of observations and standard deviation in parenthesis. *: Value slightly lower than the precision level of the GPS. / Distance parcourue (en mètres) entre «tracking» consécutifs (deux ou plus) réalisés en 2 jours (intervalle : 3-28 heures). Le nombre d'observations et l'écart type sont entre parenthèses. *: valeur légèrement inférieure à la précision du GPS.

Fish code	Month		
	July	August	September
53	—	148 (n=1)	143 (n=1)
58	86 (n=1)	45 (n=1)	90 (n=1)
68	—	119 (n=3; s.d.=56)	46 (n=1)
70	30 (n=1)	63 (n=3; s.d.=46)	48 (n=1)
80	72 (n=1)	*8 (n=1)	92 (n=1)
77	—	197 (n=1)	144 (n=1)
78	—	143 (n=3; s.d.=23)	—

(s.d.=88; n=13) from their sites of capture during the first tracking after they had returned.

Once the grouper returned to their sites of capture, they showed site fidelity. Movements of the fish (group 1) between monthly/bimonthly trackings ranged from 20 to 500 m, with individuals averaging distances of 103 m (s.d.=72) to 193 m (s.d.=92) over the one year period of the study (figure 2). These were only slightly larger than those observed on a daily basis (8-197 m; table II). At this stage, given the small number of fish tagged, no apparent relation between

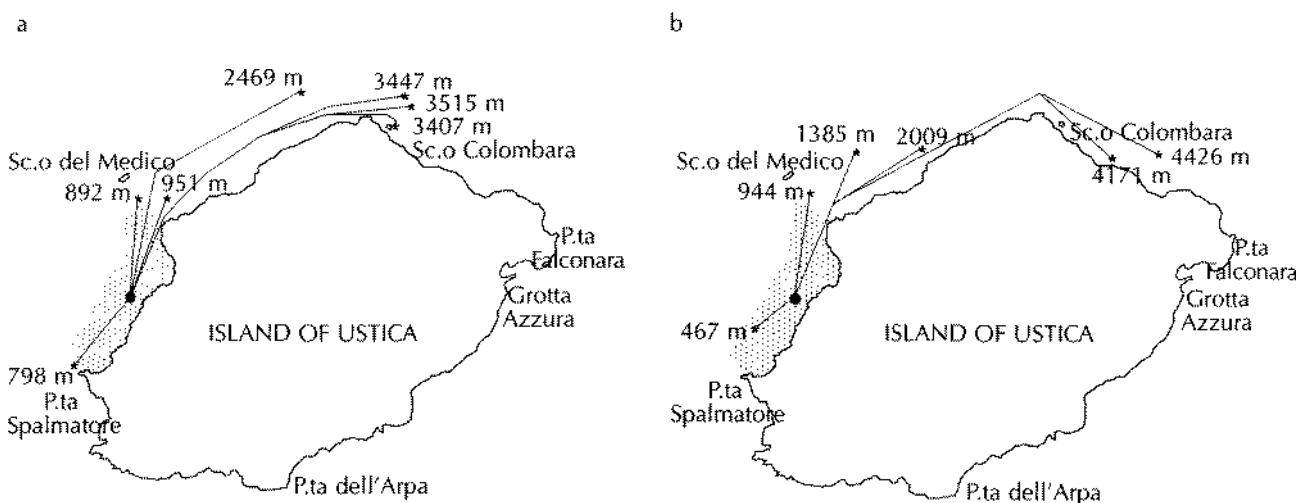


Figure 1 - Homing of dusky grouper following release in the core area of the marine reserve in (a): 25 November 1997 (group 1) and (b): 30 October - 6 November 1998 (group 2). The straight lines represent the shortest distances (given next to site of capture) between the site of release (•) and the sites of capture (*). The stippled area represents the core area of the marine reserve. / Retour au gîte des mérour noirs après le lâcher dans l'aire centrale de la réserve marine (a) : le 25 novembre 1997 (groupe 1) et (b) : le 30 octobre - 6 novembre 1998 (groupe 2). Les lignes droites représentent les distances les plus courtes (indiquées près du site de capture) entre le site de lâcher (•) et les sites de capture (*). La zone ombrée représente la réserve intégrale.

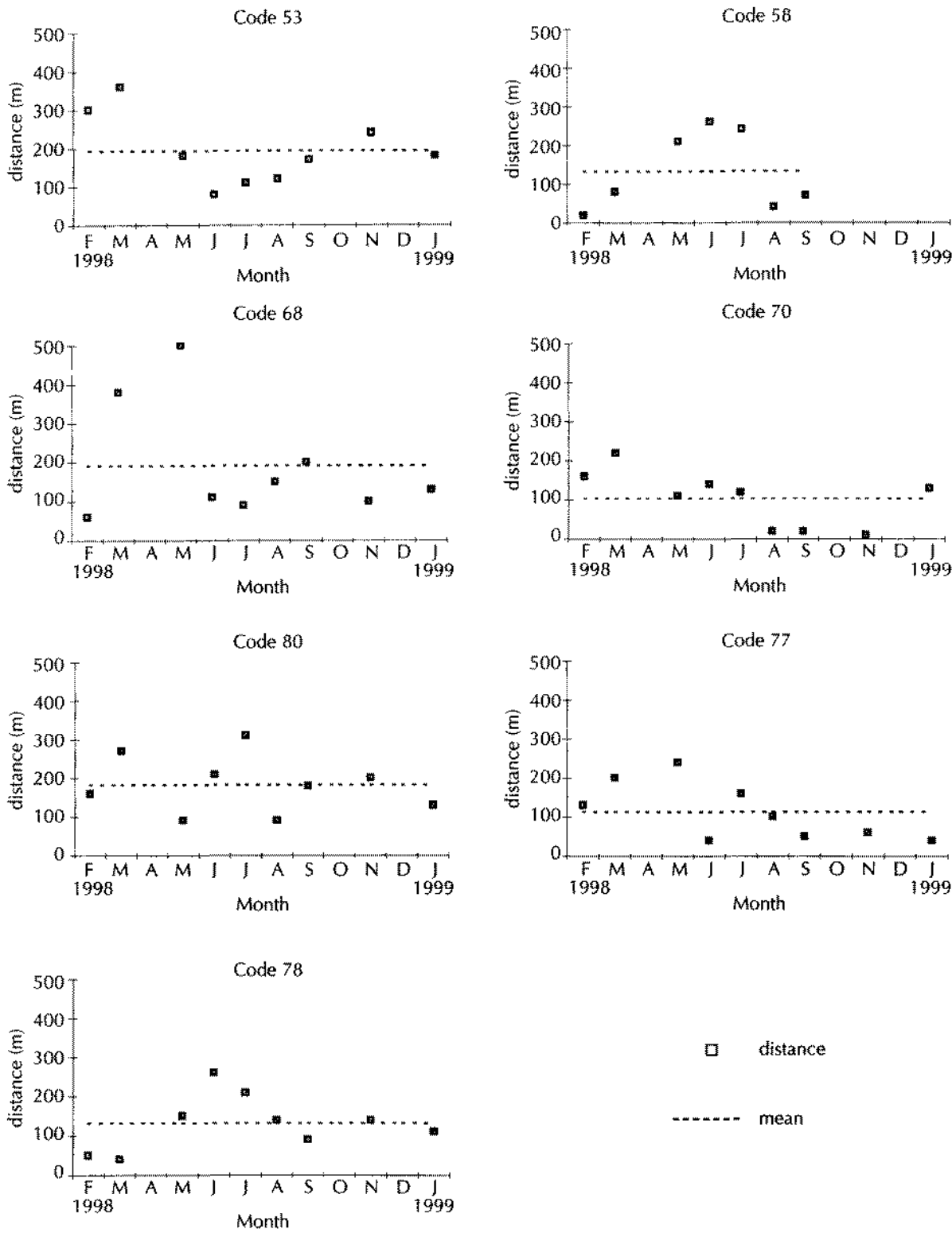


Figure 2 - Monthly/bimonthly distances moved between successive trackings for the dusky grouper released in 1997 (group 1) once they had returned to their sites of capture. For February 1998, distance was calculated as that between the fish's location and its capture site. Broken lines represent the mean distances during the tracking period for the individual fish. No data were available for fish code 58 after November 1998, as it was caught in the fishery. / Distance parcourue mensuellement/bimensuellement entre «tracking» consécutifs pour les mérous noirs relâchés en 1997 (groupe 1), après le retour aux sites de capture. En février 1998, la distance a été calculée entre la localisation du poisson et son site de capture. Les lignes hachurées représentent les distances moyennes durant la période du tracking. Pour le poisson portant le code 58, il n'y a pas de données après novembre 1998, car il a été capturé (pêche).

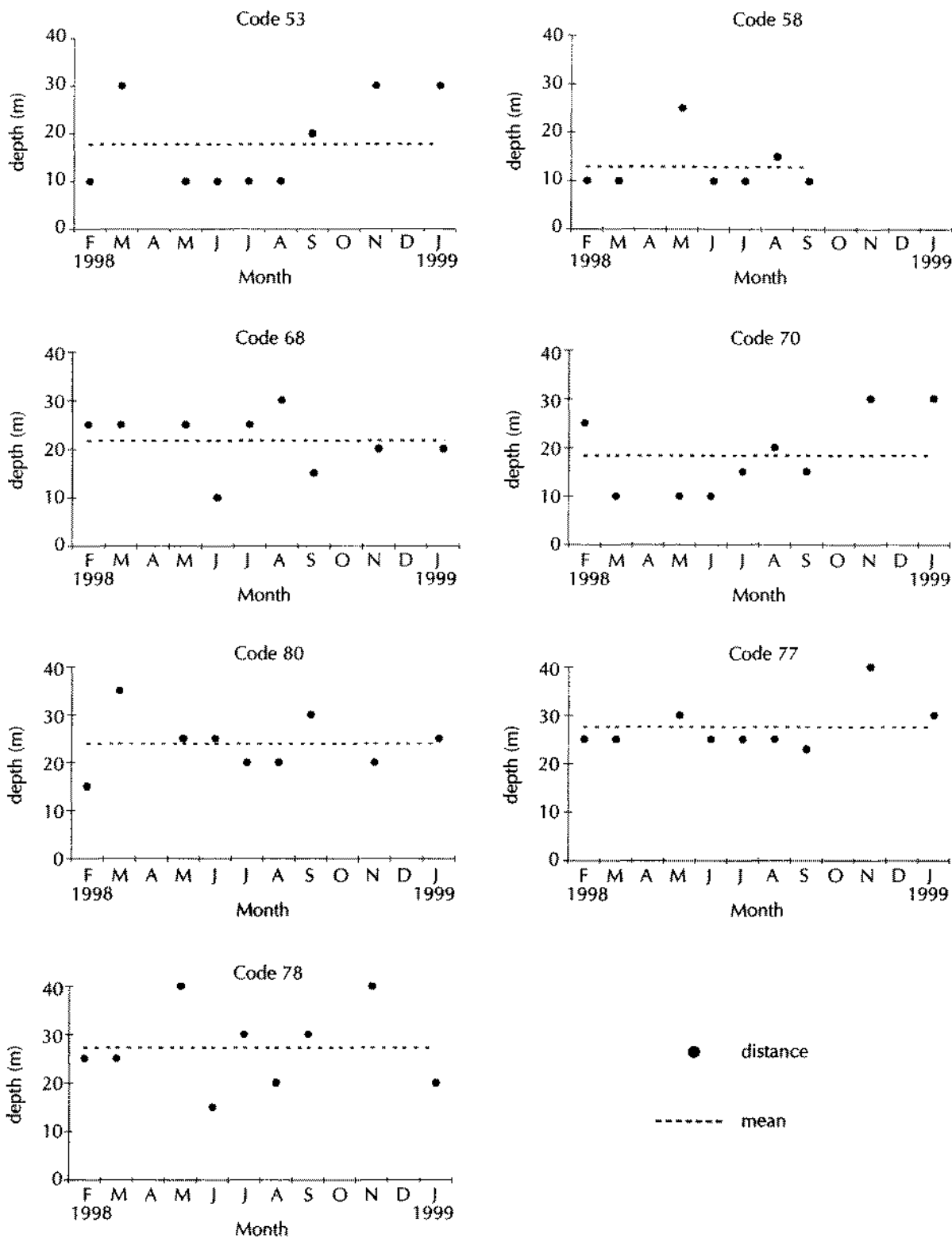


Figure 3 - Monthly/bimonthly bottom depth at each location once the fish released in 1997 (group 1) had returned to their sites of capture. Broken lines represent the mean depths during the tracking period for the individual fish. No data were available for fish code 58 after November 1998, as it was caught in the fishery. / Profondeur mensuelle/bimensuelle à chaque position, après le lâcher des mérus noirs en 1997 (groupe 1) et le retour à leurs sites de capture. Les lignes hachurées représentent les profondeurs moyennes durant la période du «tracking». Pour le poisson portant le code 58, il n'y a pas de données après novembre 1998, car il a été capturé (pêche).

the range of movements and size of fish was observed (linear correlation coefficient: -0.397). Moreover, there was no clear pattern in displacement throughout the year (figure 2). The fish were found at depths between 10-40 m, with the larger fish located in deeper waters (linear correlation coefficient: 0.846; figure 3). Average depths over the year ranged from 27.6 m (s.d.=5.2) to 12.9 m (s.d.=5.7). There was no clear seasonal pattern to the depth occupied (figure 3).

There was no mortality associated with tagging and retention of the transmitters was 100% throughout the study period for both release groups, as estimated by manual tracking. This suggests that there were no severe long-term effects of tagging.

DISCUSSION

All dusky grouper homed to their site of capture. This occurred despite them having been released into the core area of the marine reserve, an area known to have habitats suitable for the species (Vacchi *et al.*, 1999). Homing was precise and occurred independent of individual body size and period in captivity. Although the age and size at which such homing behaviour becomes established remains unknown for *E. marginatus*, our results clearly indicate that it occurs before the fish are 2 kg in weight and have reached adulthood. Homing is well documented among diadromous fish (McDowall, 1988), but is thought to be rare among other types of fishes (Gibson, 1993). For the dusky grouper, however, homing may be important in enabling the fish to effectively use knowledge about local refuges and foraging areas. It may also be important in a social context, where relationships with conspecifics are established and stabilised over long periods of interaction. What this means for management is that the relocation of dusky grouper over 2 kg to nearby areas for protection or re-establishment is unlikely to be an effective option.

The dusky grouper shows strong site fidelity throughout the year. The distances moved, however, were larger than the few meters implied by Neill (1967). Our results are more in accordance with Chauvet *et al.* (1991), as *E. marginatus* appears to use a rather wide area, that can be shared among individuals and extend over 1 to 3 hectares, when average displacements are considered. The distances moved appeared unrelated to fish size or season. Larger fish tended to be located, on average, in deeper waters than smaller fish. This has also been reported from other geographical areas (Derbal, Kara, 1995). Thus, marine reserves of a given size and incorporating a range of depths can effectively encompass the home range of the species, protecting a proportion of the population from exploitation.

CONCLUSION

We have documented homing and site fidelity in dusky grouper ranging from 2-17 kg for one year at least. The life stage at which such behaviour

becomes established, the mechanisms of orientation and the distance over which it can operate, however, remain poorly understood. Increase of knowledge in these areas will provide critical information necessary to establish appropriate management measures for this species, particularly in terms of designing and regulating marine reserves. It will also provide insights into the possibilities for and limitations of restocking and re-introduction as a mean of managing this endangered species. Furthermore, information on the dynamics of movements, habitat requirements and behaviour of the dusky grouper, mainly during spawning, would greatly improve our ability to simulate the appropriate conditions in broodstock management and aquaculture. For example, social-group structure in captive conditions might affect behaviour resulting in a failure to mature appropriately and, in turn, poor egg quality (Spedicato *et al.*, 1995, 1998).

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