SCI. MAR., 63 (3-4): 209-218 SCIENTIA MARINA 1999

BIOLOGY AND FISHERY OF DOLPHINFISH AND RELATED SPECIES. *E. MASSUTÍ and B. MORALES-NIN (eds.)*

Traditional and experimental floating fish aggregating devices in the Gulf of Castellammare (NW Sicily): results from catches and visual observations*

G. D'ANNA[1], F. BADALAMENTI[1] and S. RIGGIO[2]

[1]C.N.R.-I.R.M.A., Laboratorio di Biologia Marina, via G. da Verrazzano 17, 91014 Castellammare del Golfo (TP), Italy.
E-mail: danna@tin.it
[2]Istituto di Zoologia, Università di Palermo, via Archirafi, 18 - I 90123 Palermo, Italy.

SUMMARY: Floating fish aggregating devices (FADs) have long been used to attract fish in NW Sicily since antiquity. Recently, a number of changes have been made to the type of material employed to construct FADs, with the aim of increasing their effectiveness. In this paper we compare the catches made at eight experimental floating FADs (polypropylene ropes frayed at the ends) with those obtained at eight traditional FADs in the Gulf of Castellammare. A total of 672 samples were collected during summer and autumn in 1995 and 1996 at the 16 FADs using a surrounding net. Visual observations of fishes associated with the FADs were also conducted to obtain qualitative information about the spatial distribution of species. A total of 1632 specimens weighing 144 kg and belonging to eight species were caught during the survey. *Seriola dumerili*, *Caranx crysos*, *C. rhonchus* and *Coryphaena hippurus* were the most frequent and abundant species accounting for 96% of the total catch. Average fish abundance and weight, characterised by high variance, were significantly higher at the sites with experimental FADs than at the sites with traditional FADs. *S. dumerili* was the only species with higher catches around the experimental FADs. Some spatial and temporal variations in fish abundance and size were also detected. Younger individuals of *S. dumerili* were observed to show high affinity for the experimental FAD tufts.

Key words: FADs, *Seriola dumerili*, NW Sicily.

INTRODUCTION

Flotsam and other fish aggregating devices (FADs) have been used throughout history by fishermen to improve pelagic fish catches, especially in the central and western Mediterranean basin (Bombace, 1989; Galea, 1961; Massutí and Morales-Nin, 1991; 1995). Oceanic and coastal FADs provide the opportunity to decrease both searching time and operating costs for fishing vessels (Brock, 1985; Raymond *et al*., 1989). While the traditional FADs used in the Mediterranean have undergone few modifications, in the United States both the design and the durability of FADs have been improved for commercial fishing and recreational purposes in recent years (Beets, 1989; Murray *et al*., 1987; Rountree, 1990; Raymond *et al*., 1989).

In Sicily the use of traditional FADs, constructed with vegetal materials, is linked exclusively to the presence of economically important species of pelagic fish along the coast, such as the greater amberjack *Seriola dumerili* and the dolphinfish *Coryphaena hippurus* (Potoschi and Sturiale, 1996). Commercial fishing for adults of these two species takes place during May and June while the young are caught from August until December (Andaloro

*Received March 5, 1998. Accepted February 2, 1999.

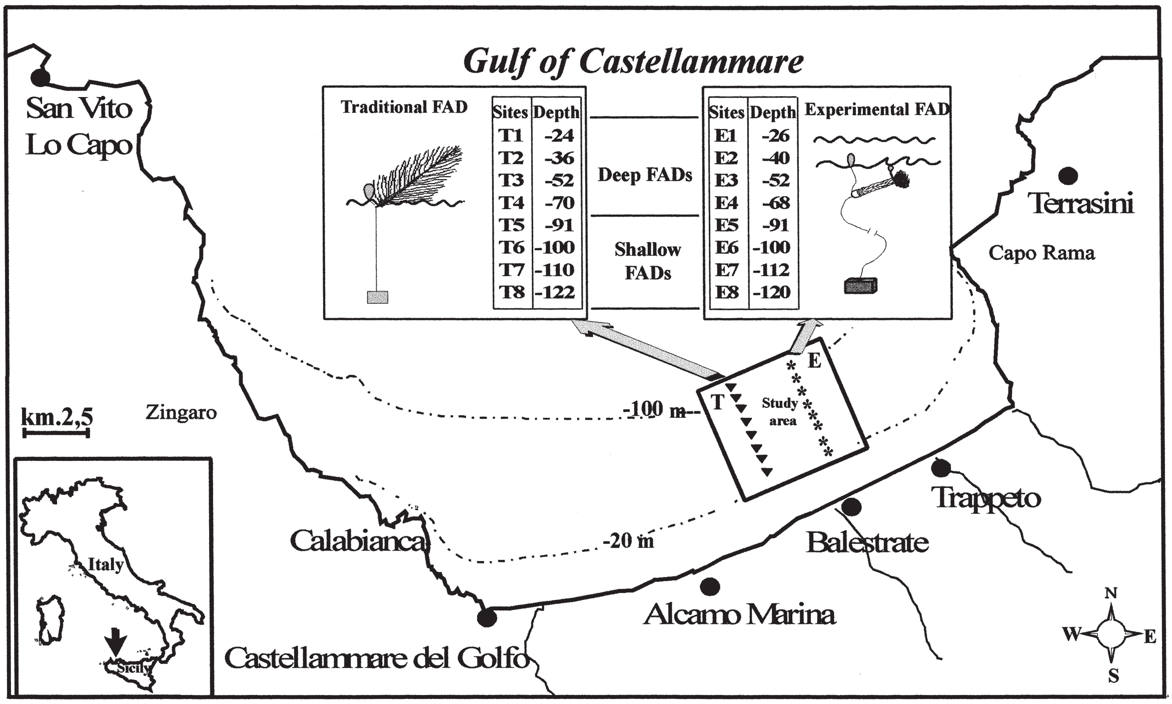

FIG. 1. – Map of study area showing location of transects with traditional FADs (T1-T8) and experimental FADs (E1-E8). Shallow and deep FADs are also indicated. Depth in meters. A schematic representation of the two types of FAD is shown in Figure 2.

et al., 1992; Lazzari and Barbera, 1989; Potoschi *et al.*, 1999).

The arrival of the young *Seriola dumerili* and *Coryphaena hippurus* along the Sicilian coasts opens the season of so-called shade fishing (Bombace, 1989), which is economically important for many small Sicilian fisheries (Cannizzaro *et al.*, 1999). Before reaching the FAD area juveniles aggregate under floating objects such as refuse or vegetal materials. These objects have been seen to play an important role in the diffusion and transport of young fishes towards coastal areas (Druce and Kingsford, 1995; Kingsford, 1992).

From July to December local fishermen position several hundred FADs in the Gulf of Castellammare. These traditional FADs are constructed using palm leaves and/or green canes (Mazzola *et al.*, 1993). Fishermen distribute FADs along transects extending several kilometres perpendicular to the coast. Transects extend from shallow (-15 m) coastal water offshore to about 500 m of depth. In recent years FADs have also been used to catch juvenile of *Seriola dumerili* for rearing in open sea cages in several areas of Sicily (Giovanardi *et al.*, 1984; Mazzola *et al.*, 1996; Porrello *et al.*, 1993).

The data reported in this paper were collected as part of a larger project carried out on the Gulf of Castellammare, aimed at studying the role played by artificial structures in aggregating the juveniles of some commercial species. This paper compares the effectiveness of experimental FADs with that of traditional floating FADs.

MATERIALS AND METHODS

Study site

The Gulf of Castellammare is a broad indentation on the NW coast of Sicily, lying in the South Tyrrhenian Sea at 38°03’ N; 12°54’ E at its midpoint (Fig. 1). Its coastline is over 70 km long and encloses an area of about 300 km^2. The eastern and western sides are characterised by steep dolomitic cliffs, while the whole central side consists of narrow sandy beaches.

The Gulf was considered an important fishing area in an early investigation carried out by Arena and Bombace (1970). The Gulf hosts 5 small-scale fisheries (Arculeo *et al.*, 1988; D’Anna *et al.*, 1992) exploiting pelagic fish such as *Seriola dumerili* and *Coryphaena hippurus* which are associated with traditional FADs known as “cannizzi” (Mazzola *et al.*, 1993; Potoschi and Sturiale, 1996).

Sampling design

In July 1995, two transects were randomly chosen from within a network of FADs present in the central part of the Gulf, between depths of 20 and 120 metres. The study was carried out from July to November in both 1995 and 1996. In one transect the palm leaves were replaced with experimental FADs. The transect with the experimental FADs was labelled E-FADs and that with the traditional FADs as T-FADs (Fig. 1).

The two transects included a set of 8 FADs each, positioned at equal depths and at an average distance of approximately 500m from each other. The 16 FADs were labelled as follows: from T1 to T8 at T-FADs transect and from E1 to E8 at E-FADs transect. The FADs of each transect were grouped into shallow FADs (at depths ranging from 24 m to 70 m) and deep FADs (at depths ranging from 91 m to 122 m) (Fig. 1).

The basic experimental FAD unit consists of buoyant multifilament polypropylene ropes, each with a diameter from 8 to 10 cm. Each FAD is 3m long and frayed at the free end (Fig. 2). Experimental FADs are low cost, being constructed from recycled orange rope and are available in large quantities. The traditional FADs are constructed from palm leaves cut from trees in the coastal towns along the Gulf. Both types of FAD were anchored with a rope to a ballast weighing 30-40 kg. Buoys were attached to the FADs to increase floatation and facilitate their location (Fig. 2).

Sampling collection and data analysis

During the two sampling periods in 1995 and 1996, a total of 672 fish collections were made on the 16 FADs, using a small fishing boat. Samples were collected with a surrounding net without purse lines. The net consisted of a central bunt in the form of a 10 metre-long spoon and two lateral wings, each 40 m long. The length of the stretched mesh ranged from approximately 93 mm at the beginning of the wings to 54 mm near the bunt. The height of the wings ranged from 4 m to 8 m. The equipment employed was similar to that described by Massutí and Morales-Nin (1991) and Potoschi and Sturiale (1996) but with the dimensions of the net halved to speed up the fishing process and increase its effectiveness, especially in catching juveniles.

Underwater visual observations were also conducted to obtain qualitative information on the spatial distribution of fishes and in particular of *Seriola dumerili,* in relation to the FADs.

During both years, samples were collected on a weekly basis from July to November in 1995 and from August to October in 1996.

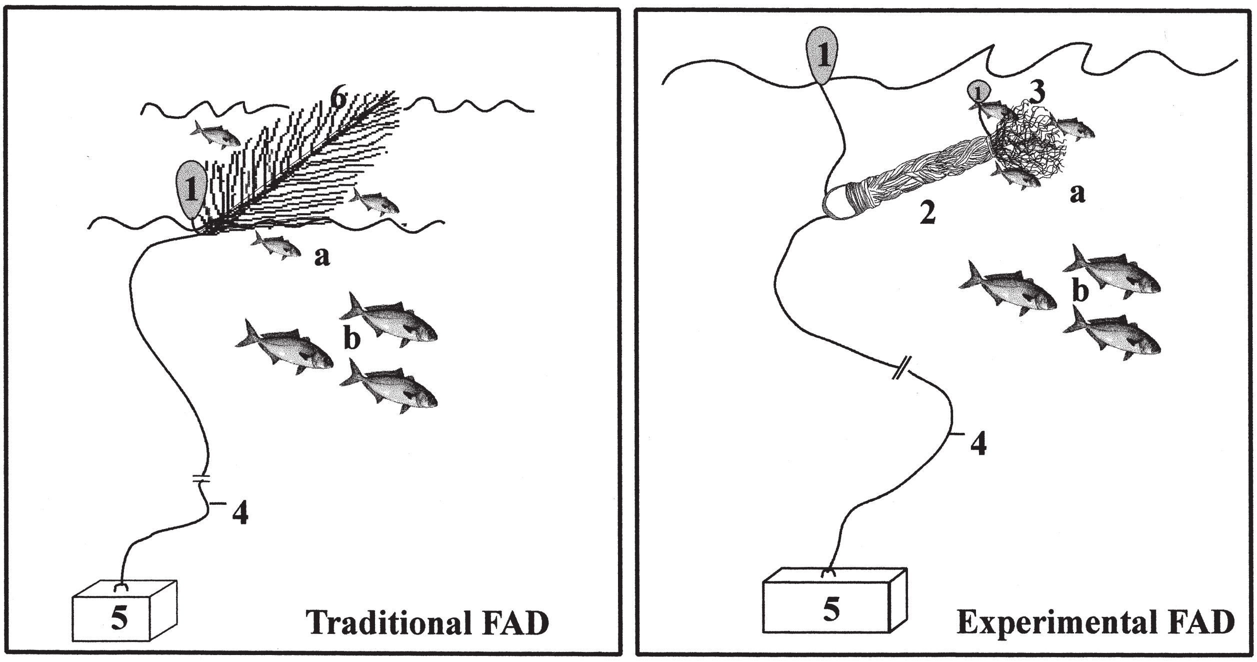

FIG. 2. – Schematic representation of the components of traditional and experimental FADs: 1 = signalling buoy; 2 = 2-metre-long buoyant multifilament polypropylene rope; 3 = one-metre-long frayed tuft of FAD; 4 = rope joining FAD to anchor; 5 = weight of 30-40 kg; 6 = 2-3 metre-long palm leaf. a = greater amberjack with total length < 10 cm; b = greater amberjack with total length between 15 and 25 cm.

All specimens were identified to the species level, counted (No.), weighed (W in g) and measured (total length in mm). The following indices were used in order to estimate the efficiency of the two types of FADs: percentage frequency of occurrence for each species (F%) at each transect; percentage contribution in number (no.%) and weight (w%) of each fish species to the total annual catch at each transect. Monthly and spatial variations in fish abundance and weight were also considered for the two types of FAD.

Differences between the F% values at the two transects (T-FADs and E-FADs) were analysed using the normal test (Fleiss, 1981). Spatial differences in the numbers of individuals (No.) and in the relative weight (W) at the two transects were detected using the Mann-Whitney U test while comparisons between the FADs of the two transects and temporal differences were investigated using the Kruskall-Wallis test (Siegel, 1956). The T- test was used to compare fish sizes.

RESULTS

During the two sampling campaigns a total of 1632 individuals belonging to eight species were caught, with a total weight of approximately 144 kg. The list of species caught, their numbers (No.) and weight (W) for each of the 16 sites and for each transect (E-FADs and T-FADs) are reported in Table 1 and 2.

TABLE 1. – List of species caught during the 1995 and 1996 sampling periods at 8 floating experimental FADs (E1...E8) situated from the coast up to a depth of c.a. 120 m. Shallow FADs = from 24 m to 70 m; Deep FADs = from 91 m to 122 m.; No. = number of specimens; W(g) = weight in grams.

				EXPERIMENTAL FADs					
Sites	E1	E2	E3	E4	E5	E6	E7	E8	Total FADs
Depth (m)	26	40	52	68	91	100	112	120	
Pooled FADs	SHALLOW FADs				DEEP FADs				
Samples collected	21	21	21	21	21	21	21	21	168
Period of sampling				JULY - NOVEMBER 1995					
SPECIES	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)
CARANGIDAE									
Caranx crysos	112 4983	69 4432	61 2377	17 799	12 597		8 368		279 13557
Caranx rhonchus	23 1037	6 501	6 248	3 137	1 54				39 1977
Lichia amia				1 110					1 110
Naucrates ductor			2 378	5 1425					7 1802
Seriola dumerili	89 4691	26 2704	61 5031	11 1764	102 3773	6 110	3 55		298 18128
CORYPHAENIDAE									
Coryphaena hippurus	25 5141		10 1355	5 900					40 7397
SCOMBRIDAE									
Thunnus thynnus			1 99						1 99
BALISTIDAE									
Balistes carolinensis			12 349						12 349
Number of species	4	3	7	6	3	1	2		8
Total No. and W	249 15853	101 7636	153 9838	42 5135	115 4424	6 110	11 423		677 43419
Period of sampling				JULY - NOVEMBER 1996					
Samples collected	21	21	21	21	21	21	21	21	168
SPECIES	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)	No. W(g)
CARANGIDAE									
Caranx crysos	85 2177	44 1335	32 1071	9 322		20 506		47 1199	237 6610
Caranx rhonchus	8 224	3 110	3 135			1 30		3 87	18 586
Coryphaena hippurus	9 2951			6 899		25 9011	2 397	64 24082	106 37339
Naucrates ductor						3 247			3 247
Seriola dumerili	22 461	29 1273	13 430	18 1102	12 943	7 555	3 479		104 5243
SCOMBRIDAE									
Thunnus thynnus						1 83			1 83
BALISTIDAE									
Balistes carolinensis								9 284	9 284
Number of species	4	3	3	3	1	6	2	4	7
Total No. and W	124 5813	76 2718	48 1636	33 2323	12 943	57 10432	5 876	123 25652	478 50392

TABLE 2. – List of species caught during the 1995 and 1996 sampling periods at 8 floating traditional FADs (T1…T8) situated from the coast up to a depth of c.a. 120 m.; Shallow FADs = from 24 m to 70 m; Deep FADs = from 91 m to 122 m.; No. = number of specimens; W(g) = weight in grams.

	TRADITIONAL FADs															
Sites	T1		T2		T3		T4		T5		T6		T7	T8	Total FADs	
Depth (m)	24		36		52		70		91		100		110	122		
Pooled FADs	SHALLOW FADs								DEEP FADs							
Samples collected	21		21		21		21		21		21		21	21	168	
Period of sampling	JULY - NOVEMBER 1995															
SPECIES	No.	W(g)	No.	W(g)	No.	W(g)	No.	W(g)	No.	W(g)					No.	W(g)
CARANGIDAE																
Caranx crysos	94	5036	35	2069			8	409							137	7513
Caranx rhonchus	16	794	5	291			2	79							23	1164
Lichia amia	1	115													1	115
Naucrates ductor			10	2312					4	795					14	3108
Seriola dumerili	54	5301	5	487	5	701	4	274	40	2071					108	8834
CORYPHAENIDAE																
Coryphaena hippurus			25	13617	10	1568	10	1356							45	16541
SCOMBRIDAE																
Thunnus thynnus																
BALISTIDAE																
Balistes carolinensis	5	980	7	1510			7	588	3	555					22	3633
Number of species	5		6		2		5		3						7	
Total No. and W	170	12226	87	20287	15	2269	31	2706	47	3421					350	40909
Period of sampling	JULY - NOVEMBER 1996															
Samples collected	21		21		21		21		21		21		21	21	168	
SPECIES	No.	W(g)	No.	W(g)	No.	W(g)	No.	W(g)	No.	W(g)	No.	W(g)			No.	W(g)
CARANGIDAE																
Caranx crysos			13	397	18	556	10	304	18	563	15	554			74	2374
Caranx rhonchus			2	77	2	73			2	76					6	225
Coryphaena hippurus			8	2767	2	192			1	145	12	2626			23	5730
Naucrates ductor									1	90					1	90
Seriola dumerili			13	391	6	301	2	162	1	85	1	174			23	1113
BALISTIDAE																
Balistes carolinensis																
Number of species			4		4		2		5		3				5	
Total No. and W			36	3632	28	1122	12	466	23	959	28	3354			127	9532

The F% values for *Seriola dumerili*, *Caranx crysos* and *C. rhonchus* were significantly higher for the E-FADs transect (P< 0.01) during both 1995 and 1996. *Coryphaena hippurus* occurred more frequently at the E-FADs (P< 0.05) only in 1996. *Balistes carolinensis* reached significantly higher F% values at the T-FADs (P< 0.01), but only in 1995. No significant difference was found in the F% values for the other species (Fig. 3).

In 1995, eight species and 1027 individuals with a total weight of approximately 84.3 kg were caught on the two transects. The average number and weight of fish (± s.d.) was 4±10.6 and 258g±692 for E-FADs (Table 1) and 2.1±6.9 and 243.5g±1157 for T-FADs (Table 2). The experimental FADs contributed 66% in number and 51% in weight to the total catch against 34% and 49% respectively for the traditional FADs. The highest average values of number and weight were observed at E1, E5, E3 and at T1, T2, T5 but they were highly variable (Fig. 4).

Seriola dumerili, *Caranx crysos* and *Coryphaena hippurus* were the most abundant species in terms of both percentage number and weight during 1995. *Seriola. dumerili* and *Caranx crysos* were most abundant at the E-FADs transect, while *Coryphaena hippurus* was more abundant at the T-FADs transect (Fig. 5). Average total length (± s.d.) of the fishes caught at both transects in 1995 is shown in Figure 6.

In 1996, seven species and 605 specimens with a total weight of approximately 60 kg were caught on the two transects. The average number and weight of fish (± s.d.) was 2.8±9.7 and 300g±1670 for the E-FADs and 0.8±2.8 and 56.7g±266.7 for the T-FADs (Tab. 1). The experimental FADs contributed

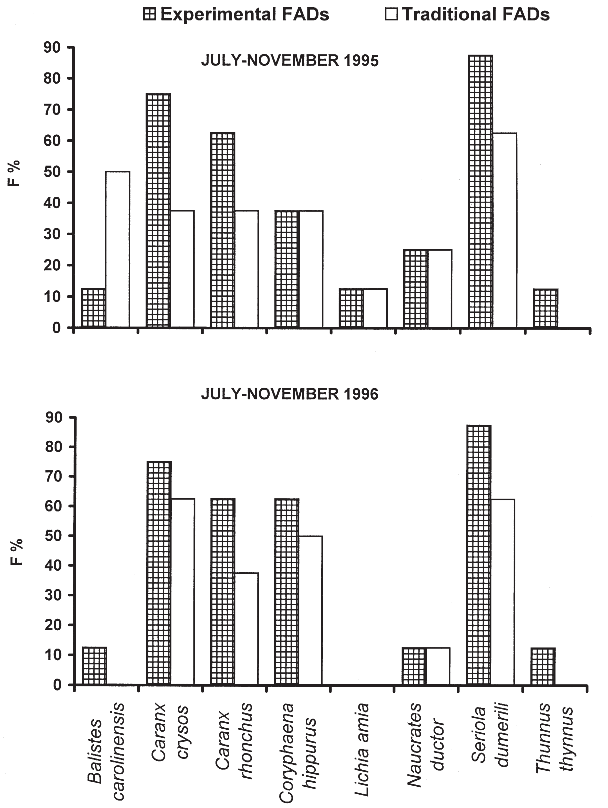

FIG. 3. – Percentage frequency of occurrence of species (F%) at the two types of FAD during the 1995 and 1996 sampling periods.

79% in number and 84% in weight to the total catch against 21% and 16% respectively for the traditional FADs. The highest average values of number and weight were observed at E1, E6, E8 and at T2, T6 but they were highly variable (Fig. 4).

In 1996, *C. crysos* showed the largest percentage contribution in number caught at the E-FADs transect (39%), followed by *Coryphaena hippurus* (17%) and *Seriola dumerili* (17%). The highest contribution in terms of weight was from *C. hippurus* at the E-FADs, representing 62% of the weight of the total 1996 catch (Fig. 5). The average total length (± s.d.) of the fishes caught at both E-FADs and T-FADs transects in 1996 is shown in Figure 6.

Overall, taking into account the data from the two sampling periods, the fish average number and weight were significantly higher (P< 0.05) at the E-FADs. However, comparison between species showed that only *Seriola dumerili* was significantly more abundant (No., P<0.001 and W, P<0.01) at the E-FADs transect.

The comparison of the 16 FADs of the two transects showed only for *C. crysos* significantly higher number values at E2 and E3 in the E-FADs transect compared to the values obtained at T2 and T3 in the T-FADs transect. Comparison of the total length of

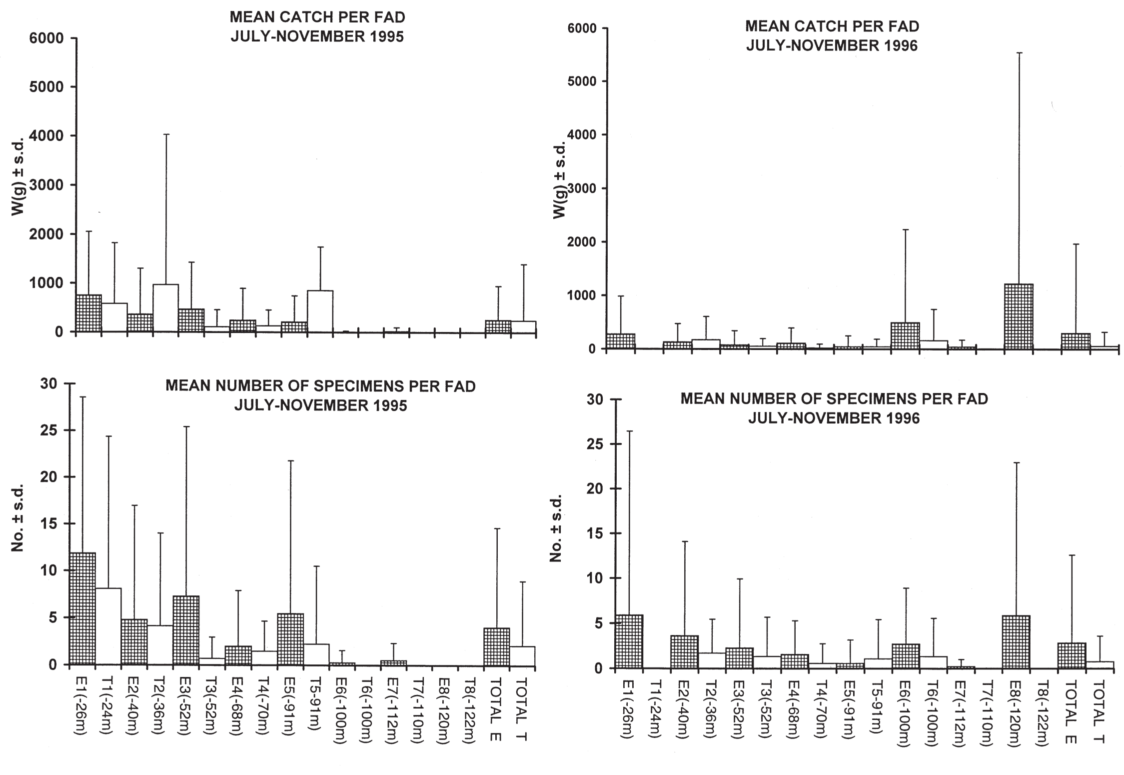

FIG. 4. – Weight (W) and average number of individuals (No.) of species caught at each FAD. s.d. = standard deviation. E1..E8 = experimental FADs; T1..T8 = traditional FADs.

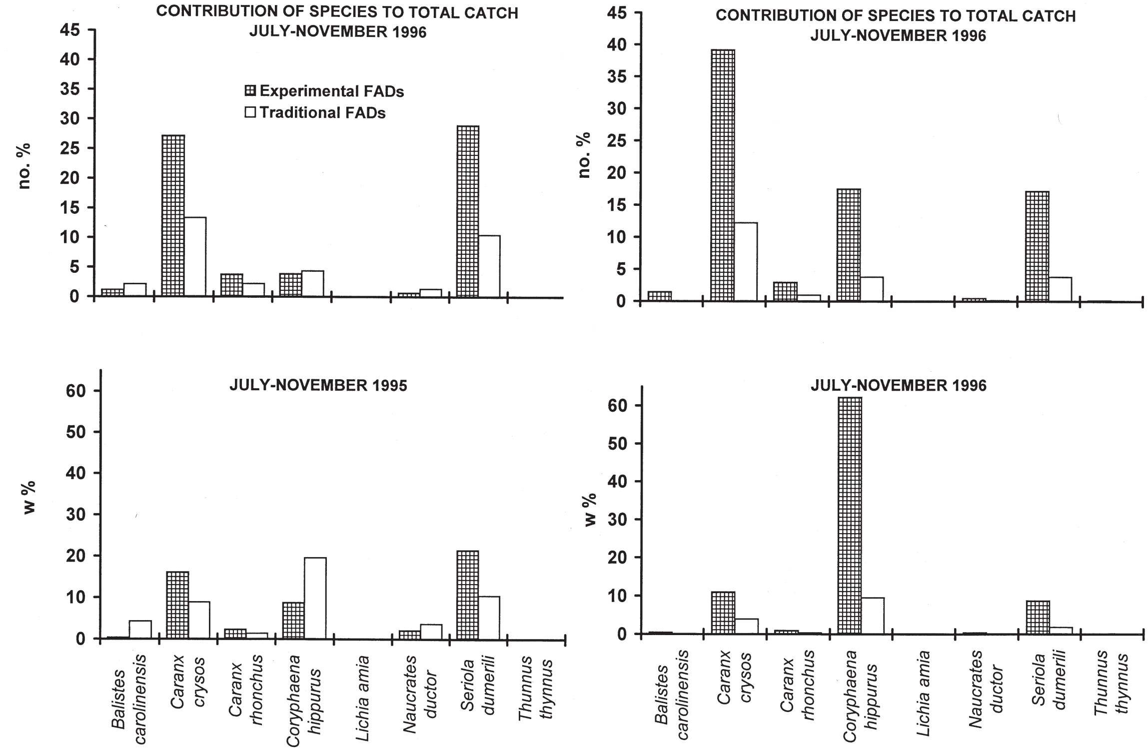

FIG. 5. – Percentage contribution in number of individuals (no.%) and in weight (w%) of each species to the annual total catch around only experimental and traditional FADs.

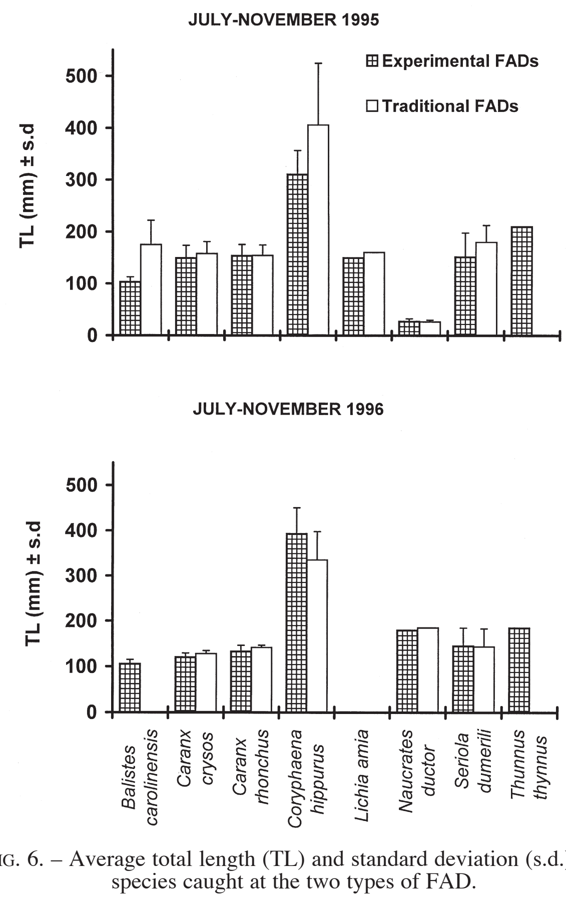

FIG. 6. – Average total length (TL) and standard deviation (s.d.) of species caught at the two types of FAD.

the same species caught at the two transects did not reveal any significant difference.

In 1995 both types of FAD showed significant temporal variations ($P<0.05$) in number and weight, with the highest monthly mean values in November. Also in 1996 values for number and weight showed significant ($P<0.01$) temporal differences, with the highest monthly mean number and weight values in October for E-FADs and in October and September for T-FADs (Fig. 7).

Figure 8 shows the temporal variations in the monthly mean total length of the most abundant fishes caught around the two types of FAD. *Coryphaena hippurus* and *Seriola dumerili* showed the highest increments in size.

In 1995 statistical analysis highlighted spatial variations within the E transect with the No. values of *Caranx crysos* significantly higher ($P<0.05$) at the shallow FADs (9.3 ± 17.7) than at the deep FADs (3.4 ± 6.1). In the same year *Seriola dumerili* showed a mean TL which was significantly higher at the shallow E-FADs (197.6 mm ± 30.6) than that recorded at the deep E-FADs (138.1 mm ± 11.4).

In 1996 significant differences in total catch (W) and in TL of *Seriola dumerili* were detected between shallow E-FADs (670g ± 715 ; 144.8 mm ± 34.1)

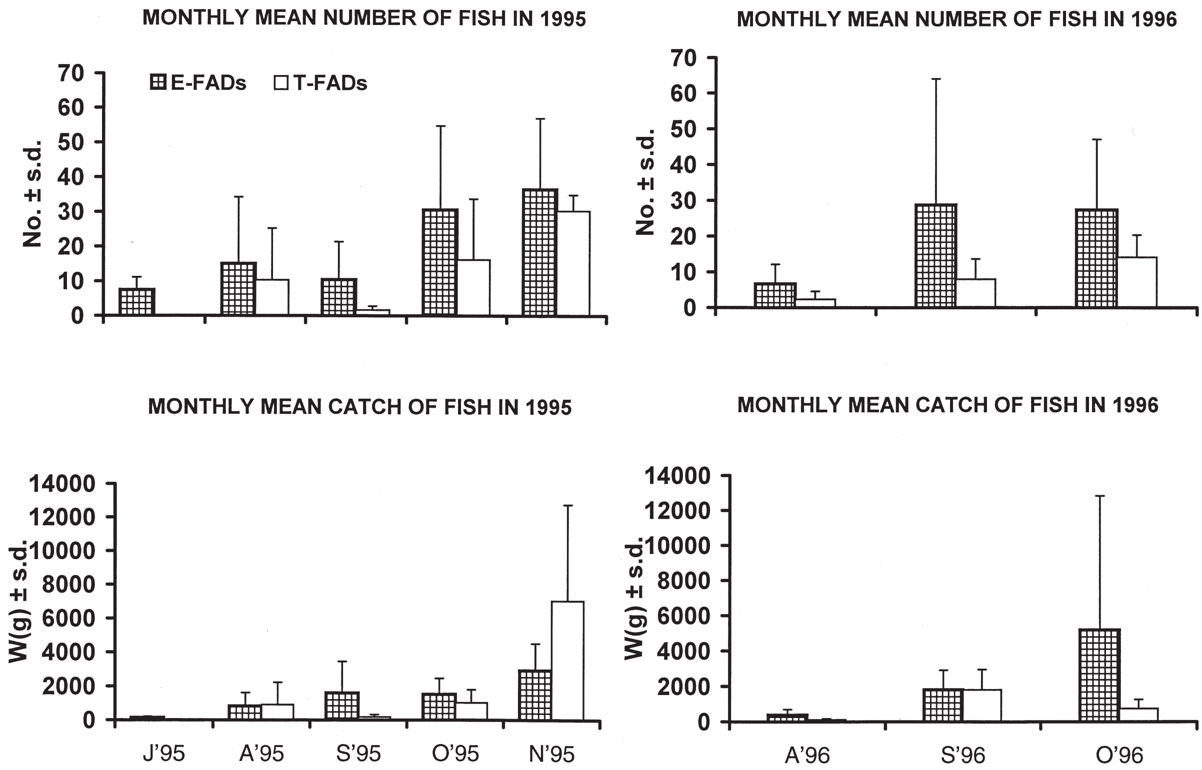

FIG. 7. – Temporal variation in the number of fishes (No.) and in the catches (W) around traditional FADs (T-FADs) and experimental FADs (E-FADs) during the 1995 and 1996 sampling periods. s.d. = standard deviation.

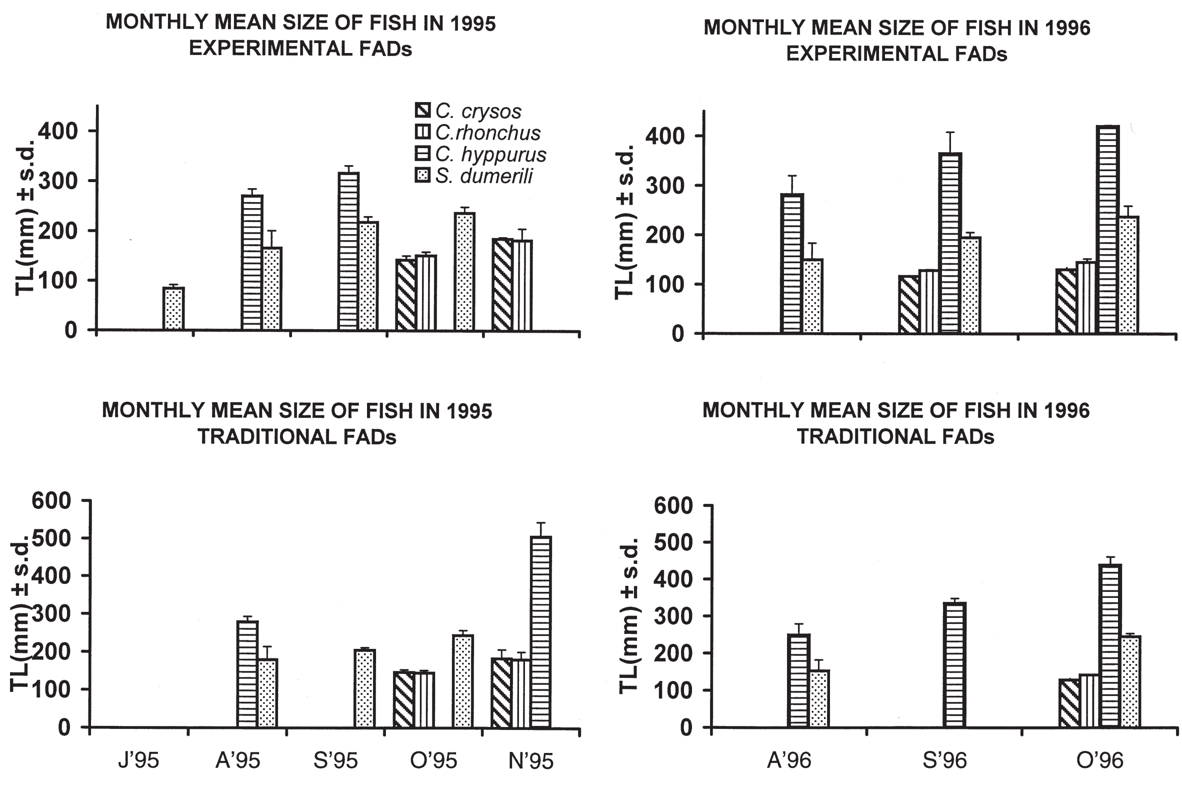

FIG. 8. – Temporal variation in total length (TL) of four fishes caught around the two types of FAD during the 1995 and 1996 sampling periods.. s.d. = standard deviation.

and deep E-FADs (3423g ± 5854 ;197.1 mm ± 27.5). At the T-FADs, the TL of *Seriola dumerili* was significantly higher at the deep FADs (217 mm ± 38.9) than at the shallow FADs (148.1± 28.1).

On the whole, the visual observations carried out underwater did not find any particular difference in the spatial distribution of species in relation to the characteristics of the two types of FAD. The distribution pattern was very similar to that described by Massutí and Reñones (1994), with a few differences concerning the behaviour of the two different size classes of Carangids and of *Seriola dumerili* in particular. The smaller *Seriola dumerili* (TL< 10 cm) were almost always observed very close to the FADs and, at the first sign of danger (for example an approaching diver), moved under the palm leaves of the traditional FADs or disappeared completely among the frayed tufts of the experimental FADs (Fig. 2). The behaviour of larger individuals (15 cm <TL < 25) was different. At the approach of a diver or a boat towards the FAD, these individuals quickly moved away in an oblique or downward direction (Fig. 2).

DISCUSSION

After the two year survey on the FADs in the Gulf of Castellammare we can state that the polypropylene ropes are more effective at attracting juvenile fishes than are the traditional FADs made with vegetal material.

The most important difference between the two types of FADs is reflected in the greater abundance of the carangids and in particular *Seriola dumerili*. Only this species showed abundance values which were consistently significantly higher at the experimental FADs. Moreover, all three species of carangids showed significantly higher F% values at the E-FADs transect throughout the study.

Coryphaena hippurus, on the other hand, was more abundant at the traditional FADs in 1995, while in 1996 it was more abundant at the experimental FADs. *Balistes carolinensis* showed greater affinity for the traditional FADs, although at a low frequency.

From these observations, it emerges that the effectiveness of the experimental FADs manifests itself in a higher total catch, in a higher frequency of occurrence of the three carangid species and in a greater capacity to attract juveniles of *Seriola dumerili*. The affinity shown by the greater amberjack towards the polypropylene FAD is supported by a previous study carried out on bottom FADs in the Gulf of Castellammare (D'Anna *et al*., 1997), where the basic element employed for the construction of the bottom FAD was the same as that utilised in the present experiment. The results obtained from the bottom FADs have provided information regarding their capacity to aggregate *Seriola dumerili* with a TL 40 cm greater (D'Anna *et al*., 1997) than those attracted to the surface FADs (TL values between 7 and 25 cm).

The temporal variations in the number (No.) and weight (W) of fish around the two types of FAD are mainly due to the different periods of recruitment of the fish and to their different growth ratios. In the study area, *Seriola dumerili* is already present around the FADs in July, with *Coryphaena hippurus* arriving in August and other carangids appearing from September. The significant temporal differences in catch, on the other hand, are due to the high growth ratios of *S. dumerili* and *C. hippurus* in their first stage of life (Badalamenti *et al*., 1998; Murray, 1985). The spatial differences in number and size between shallow and deep FADs are mainly due to the behaviour of the carangids. Generally speaking, the younger amberjack and *Caranx* spp. (TL<10mm) are recruited by offshore FADs and then move towards the growth area near the coast.

Many authors have studied the fish assemblages associated with FADs and several hypotheses have been put forward to explain the mechanisms regulating fish aggregations and their relationship to the characteristics of FADs (Brock, 1985; Druce and Kingsford, 1995; Helfman, 1981; Ibrahim, 1996; Massutí and Reñones, 1994; Rountree, 1989, 1990). Although there is now a better understanding of FAD associations, it is still no easy task to identify the correlations in such a complex phenomenon which involves both biological interactions between species and physical interactions between species and FAD. For this reason, identifying the factors which make the experimental FADs more effective at attracting the greater amberjack is difficult and, in any case, beyond the scope of this work. Some studies on the feeding behaviour of the greater amberjack (Badalamenti *et al*., 1995) and on the feeding cycle of juveniles at the FADs in the Gulf of Castellammare (Badalamenti *et al*., 1998), together with visual observations from this study could contribute to explain the effectiveness of the experimental FADs in recruiting the greater amberjack. The observation that the juveniles (TL<10 cm) are closely associated with the FADs can be explained by their feeding behaviour, as they feed mainly on the hypnoneustonic planktonic assemblages which characterise the most superficial layers of the sea water (< 1m of depth) (Badalamenti *et al*., 1998). In this part of the water the filaments of the experimental FAD seem to provide a safe refuge for the young amberjack, which are able to conceal themselves completely among the tufts of the ropes (Fig. 2). It would appear that the palm leaves of the traditional FADs provide less effective shelter than that offered by the ropes (Fig. 2).

The behavioural characteristic of leaving the FADs at the approach of danger was observed in larger amberjacks (15 cm <TL< 25 cm) and indicates a lower degree of dependence on the FADs, a stage which coincides with the acquisition of the definitive pescivorous feeding habit (Badalamenti *et al*., 1995).

ACKNOWLEDGEMENTS

We wish to thank Mr. Giuseppe Di Stefano for the drawings of the traditional and experimental FADs and Mrs. Marilena Coppola for her assistance in the field.

REFERENCES

Andaloro, F., A. Potoschi and S. Porrello. – 1992. Contribution to the knowledge of growth of Greater Amberjak, *Seriola dumerili*, (Cuv., 1817) in the Sicilian Channel (Mediterranean Sea). *Rapp. Comm. int. Mer Médit*., 33: 282.

Arena, P. and G. Bombace. – 1970. Bionomie benthique et faune ichthyologique des fonds de l' étage circalittoral et bathyal des golfes de Castellammare (Sicile nord-occidentale) et de Patti (Sicile nord-orientale). *Journées ichthyol*., Rome, C.I.E.S.M.: 145-156.

Arculeo M., G. D'Anna and S. Riggio. – 1988. Valutazione delle risorse demersali nell'area compresa fra Capo Gallo e Capo San Vito (Sicilia Nord - Occidentale): risultati delle campagne condotte nel 1985. *Atti Seminari Pesca e Acquacoltura. Pubbl. Min. Mar. Mercantile - C.N.R*., Vol. III:1413 - 1451.

Badalamenti, F., G. D'Anna, L. Lopiano, D. Scilipoti and A. Mazzola. – 1995. Feeding habits of young-of-the-year greater amberjack *Seriola dumerili* (Risso, 1810) along the N/W Sicilian coast. *Sci. Mar.,* 59 (3-4): 317-323.

Badalamenti F., G. Fazio, G. Zagami and G. D'Anna. – 1998. Ciclo alimentare giornaliero e selezione delle prede di *Seriola dumerili* associata a FADs di superficie nel Golfo di Castellammare. *Biol. Mar. Med.,* 5(1): 71-79.

Beets J. – 1989. Experimental evaluation of fish recruitment to combinations of fish aggregating devices and benthic artificial reefs. *Bul. Mar. Sci*., 44 (2): 973 - 983.

Bombace, G. – 1989 - Artificial reefs in the Mediterranean Sea. *Bull. Mar. Sci*., 44 (2): 1023-1032.

Brock, R.E. – 1985. Preliminary study of the feeding habits of pelagic fish around Hawaiian fish aggregation devices or can fish aggregation enhance local fisheries production*? Bull. Mar. Sci*. 37: 40-49.

Cannizzaro, L., F. D'Andrea, A. Potoschi and M. Scalisi. – 1999. Economic aspects of fishing of dolphinfish in Sicily. *Sci. Mar.*, 63(3-4): 459-464.

D'Anna, G., R. Lipari, F. Badalamenti and A. Cuttitta. – 1997. Fish colonisation of an experimental bottom FAD (fish aggregating device) in the Gulf of Castellammare (NW Sicily). *32nd European Marine Biology Symposium*. August 16-22, 1997 Lysekil, Sweden: 99.

Druce, B. E. and M.J. Kingsford. – 1995. An experimental investigation on the fishes associated with drifting objects in coastal waters of temperate Australia. *Bull. Mar. Sci*., 57(2): 378-392.

Fleiss, J.L. – 1981. *Statistical methods for rates and proportions*. 2nd ed.. J. Wiley and sons. New York, 321pp.

Galea, J.A. –1961. The "Kannizzati" Fishery. *Proc. Gen. Fish. Counc. Medit*., 6: 85-91.

Giovanardi, O., G. Mattioli, C. Piccinetti and G. Sambucci. –1984 - Prime esperienze sull'allevamento della ricciola (*Seriola dumerili*, Risso 1810) in Italia. *Rivista Italiana di Piscicoltura ed Ittiopatologia*. 19: 1-8.

Helfman, G.S. – 1981. The advantage to fishes of hovering in shade. *Copeia*, 2: 392-400.

Ibrahim, S., M.A.Ambak, L. Shamsudin and M.Z. Samsudin. – 1996. Importance of fish aggregating devices (FADs) as substrates for food organisms of fish. *Fisheries Research*, 27: 265-273.

Kingsford, M.J. – 1992. Drift algae and small fish in coastal waters of northeastern New Zealand. *Mar. Ecol. Progr. Ser*., 80: 41-45.

Lazzari, A. and G. Barbera. – 1989. Prime osservazioni sulla pesca di riproduttori di ricciola, *Seriola dumerili*, nelle Isole Pelagie. *Oebalia*, XV (2), N.S.: 645-652.

Massutí, E. and B. Morales-Nin. – 1991. La pesca de la llampuga (*Coryphaena hippurus*) en Mallorca. *Inf. Téc. Inst. Esp. Oceanogr*., 96: 1-18.

Massutí, E. and Reñones. – 1994. Observaciones sobre la comunidad de peces pelágicos asociados a objetios flotantes en aguas oceánicas de Mallorca. *Bol. Inst. Oceanogr.,* 10(1): 81-93.

Massutí, E. and B. Morales-Nin. – 1995. Seasonality and reproduction of dolphin-fish (*Coryphaena hippurus*) in the western Mediterranean. *Sci. Mar*., 59(3-4): 357-364.

Mazzola, A., L. Lopiano, G. Sarà and G. D'Anna. – 1993. Sistemi di pesca, cattura ed abitudini alimentari di *Seriola dumerili* (Risso 1810) nel Golfo di Castellammare (Sicilia occidentale). *Naturalista siciliano*, S. IV, XVII (1-2): 137-148.

Mazzola, A., G. Sarà, E. Favarolo and S. Mirto. – 1996. Sistemi di maricoltura open-sea per l'allevamento di *Seriola dumerili* (Pisces: Osteichthyes) nel Golfo di Castellammare (Sicilia Occidentale). *Biol. Mar. Medit*. 3(1): 176-185.

Murray, J.D, J.C. Howe, D.G. Lindquist and D.C. Griffith. – 1987. Using FAD's to Attract Fish at Coastal Fishing Piers. *Mar. Fish. Rev*. 49(2): 143 – 154.

Murray, P.A. – 1985. Growth and mortality in the dolphin-fish *Coriphaena hippurus* caught off Saint Lucia, W.I. *FAO Fish. Rep*., 327 Suppl.: 147-153.

Porrello S., F. Andaloro, P. Vivona and G. Marino. – 1993. Rearing trial of yellowtail (*Seriola dumerili*) in floating cage. *European Acquaculture Society, Special publications*. 18, Ghent, Belgium.

Potoschi, A. and P. Sturiale. – 1996. Distribuzione dei "cannizzi" nel Tirreno Meridionale e nello Ionio per la cattura della lampuga *Coriphaena hippurus* L., 1758. *Biol. Mar. Medit*. 3(1): 384-386.

Potoschi, A., L. Cannizzaro, A. Milazzo, M. Scalisi and G. Bono. – 1999. Sicilian dolphinfish (*Coryphaena hippurus*) fishery. *Sci. Mar.,* 63(3-4): 439-445.

Rountree, R.A. – 1989. Association of fishes with fish aggregation devices: effect of structure side on fish abundance. *Bull. Mar. Sci*., 44 (2): 960-972.

Rountree, R.A. – 1990. Community structure of fishes attracted to shallow water fish aggregation devices off South Carolina, U.S.A. *Env. Biol. Fish*., 29: 241-262.

Raymond, M.B., D.G. Itano and T.W. Buckley. – 1989. Fish aggregation device (FAD) enhancement of offshore fisheries in American Samoa. *Bull. Mar. Sci*. 44 (2): 942-949.

Siegel, S. – 1956. *Non parametric statistics for the behavioural sciences*. McGraw-Hill Book Co., New York, 312 pp.