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

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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. rhomchus 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 (Bombase, 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
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 km². 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 500 m 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 3 m 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 Massuti 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.

![Traditional FAD](image1.png)

![Experimental FAD](image2.png)

**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** | **SHALLOW FADs** | **DEEP FADs** |
| **Sites** | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | **Total FADs** |
| **Depth (m)** | 26 | 40 | 52 | 68 | 91 | 100 | 112 | 120 |  |
| **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 cryos | 112 4983 | 69 4432 | 61 2377 | 17 799 | 12 597 | 8 368 | 279 1355 |
| Caranx rhonchus | 23 1037 | 6 501 | 6 248 | 3 137 | 1 54 | 1 110 | 39 1977 |
| Lichia amia | 2 378 | 1 110 | 5 1425 |  |
| Naucrates ductor | 89 4691 | 26 2704 | 61 5031 | 11 1764 | 102 3773 | 6 110 | 3 55 | 298 18128 |
| Seriola dumerili |  |
| CORYPHAENIDAE |  |
| Coryphaena hippurus | 25 5141 | 10 1355 | 5 900 | 40 7397 |
| SCOMBRIDAE |  |
| Thunnus thynnus | 1 99 |  |
| BALISTIDAE |  |
| Balistes carolinensis | 12 349 | 12 349 |
| Number of species | 4 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 | 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) |
| **CARANGIDAE** |  |
| Caranx cryos | 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 | 22 461 | 29 1273 | 13 430 | 18 1102 | 12 943 | 7 555 | 3 479 | 104 5243 |
| Seriola dumerili |  |
| SCOMBRIDAE |  |
| Thunnus thynnus | 1 83 |  |
| BALISTIDAE |  |
| Balistes carolinensis | 9 284 |  |
| Number of species | 4 3 3 1 6 2 4  |
| Total No. and W | 124 5813 | 76 2718 | 48 1636 | 33 2323 | 12 943 | 57 10432 | 5 876 | 123 25652 | 478 50392 |
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 258±692 for E-FADs (Table 1) and 2.1±6.9 and 243.5±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).

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 300±1670 for the E-FADs and 0.8±2.8 and 56.7±266.7 for the T-FADs (Tab. 1). The experimental FADs contributed...
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. cryos* 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. cryos* 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
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 cryos 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...
hynpoeustonic 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 piscivorous feeding habit (Badalamenti et al., 1995).

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REFERENCES


