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

NOTE

Ichthyofauna associated with drifting floating objects in the Balearic Islands (western Mediterranean)*

FRANCISCO RIERA[1], AMALIA GRAU[2], ANTONIO M. GRAU[3], ELENA PASTOR[1], ANTONI QUETGLAS[1] and SEBASTIÁN POU[1]

[1] Estació d'Aqüicultura. Camí del Far s/n, 07158-Port d´Andratx. Illes Balears. España. E-mail: friera@dgpesca.caib.es
[2] SEAMASA. C/ Foners10, 07006-Palma de Mallorca. Illes Balears. España.
[3] Direcció General de Pesca i Cultius Marins. Foners 10, 07006. Palma de Mallorca. Illes Balears. España.

SUMMARY: Species composition, size range and some behavioral notes about drifting flotsam associated fish of the Balearic Islands are presented, and more detailed observations on *Seriola dumerili*, *Naucrates ductor*, *Coryphaena hippurus* and *Scomberesox saurus* are also given. 25 fish species belonging to 18 families were identified, 12 of these species and the individuals of the family Mugilidae were recorded for the first time associated with floating objects in the western Mediterranean. Most of the specimens collected were juveniles, which suggests the importance of floating objects as a nursery, and thus in the recruitment and redistribution of fishes. Analisis of two drift floating material samples show that objects of anthropogenic origin were most abundant (83.5% and 63.5%) and suggests that at present, human refuse may have taken over the role of the floating remains of marine plants for fishes in the western Mediterranean pelagic environment.

Key words: Juvenile fish, drifting flotsam, Balearic Islands, western Mediterranean.

INTRODUCTION

Several hypotheses have been put forward to explain the association of fishes with floating objects, the most important being: to enhance conditions for feeding, to provide shelter from predators and to provide a substratum in the homogeneous pelagic environment (Gooding and Magnuson, 1967; Hunter and Mitchell, 1967; Kingsford, 1992).

In the Mediterranean Sea the only available studies on fishes associated with floating objects have been mainly based on commercial catches (Massutí and Reñones, 1994) or visual censuses (Relini *et al*., 1992) under fish aggregation devices. Commercial catches provide relatively big fishes (generally greater than 15 cm TL) due to seasonal fishing (from late August to early December) and the mesh size employed, and few data about little fishes were provided by visual census (Relini *et al*., 1992). Accordingly we have little or marginal information about little fishes associated with drifting flotsam. This study deals with species composition and size distribution of the drifting flotsam associated fishes in the Balearic Islands. Some seasonal patterns and behavioral observations are also presented.

At the moment little or nothing is known about the nature or types of drifting material in the western Mediterranean. We report preliminary data about the nature of these objects.

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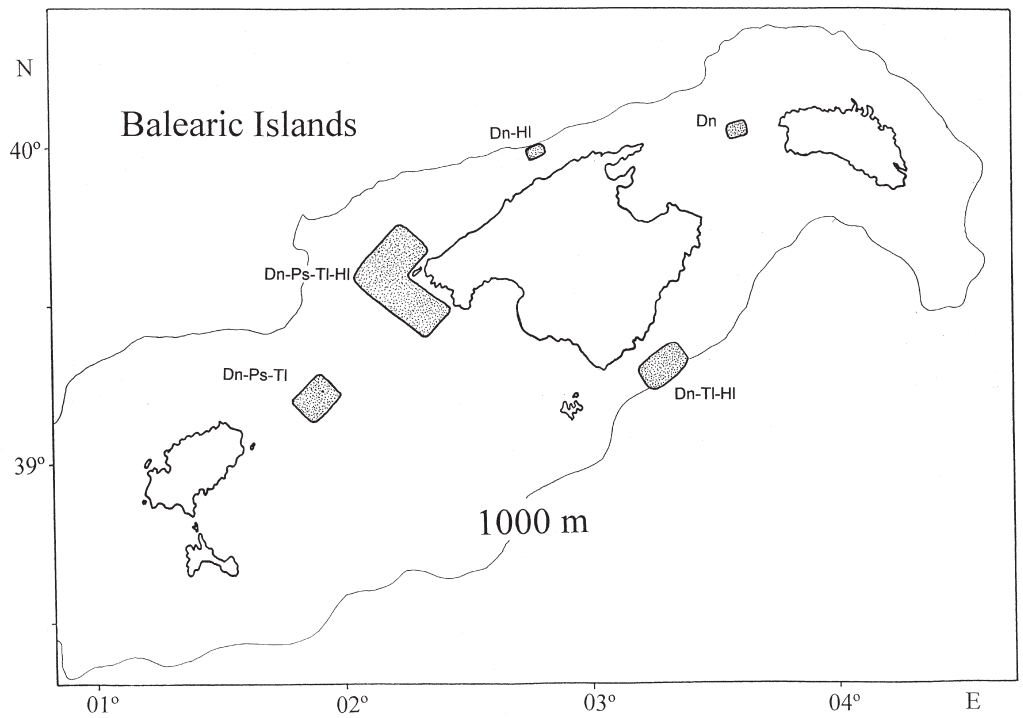

FIG. 1. – Map of the Balearic Islands with the sampling areas and the gears used (Dn: dip net; Ps: purse seine; Tl: trolling line; Hl: hand line).

MATERIAL AND METHODS

This study was made in the framework of a project carried out between 1990 and 1996 with the aim of obtaining *Seriola dumerili* juveniles for aquaculture research. As this work was not part of the main study, the sampling was sometimes out of order although it provides some unpublished data and observations that we consider to be of interest. Offshore samples and observations were carried out from July to November but data from February, May and June were also available. The sampling areas were situated in neritic and oceanic waters of the Balearic Islands in a depth range of 50 to 1100 m (Fig. 1).

The capture of specimens was based on a series of dip netting samples, supplemented by purse seine, trolling line and hand line collections (Table 1) when fishes were larger than 10-15 cm. The drifting floating objects (algae, seaweeds, gelatinous plankton, logs, marine bird feathers, plastics, etc.) were removed with a 50 cm diameter dip net with a 2 mm mesh size to catch the small-sized fishes which were sometimes associated with them.

The individuals captured were measured (total length, to the nearest mm) and weighed (to the nearest 0.01 g) in the laboratory.

Seriola dumerili juveniles were collected from August to October in littoral waters off the west of Mallorca in order to find the size and date when fingerlings change their offshore (epipelagic) habits for their littoral (epibenthic) ones. These littoral catches were mainly made with a net trap called "moruna" (Llabrés and Martorell, 1984) with a 1.5 cm mesh size, though trolling line and gillnets were also used.

In two surveys (15/07/95 and 27/10/96) in which numerous drifting objects were found in the west of Mallorca, the type of materials was evaluated: all floating objects in an area of about 1000 x 50 m (at 90 and 100 m depth approximately) were removed and classified in order to determine the percentages of natural (algae, neustonic invertebrates, feathers, logs etc.) and artificial materials (human refuse).

TABLE 1. – Number (N) of samples with captures per gear and season.

GEAR	N	Spring	Summer	Autumn	Winter
Dip net	349	26	191	102	28
Purse seine	14	-	5	9	-
Hand line	15	1	3	10	1
Trolling line	12	-	-	12	-
TOTAL	390	27	199	133	29

TABLE 2. – Family and species collected and gear used (Dn: dip net; Ps: purse seine; Hl: hand line) in the capture of drifting flotsam associated fishes in the Balearic Islands.

FAMILY	SPECIES	GEAR USED
Apogonidae	*Apogon imberbis* (Linnaeus, 1758)	Dn
Balistidae	*Balistes carolinensis* Gmelin, 1789	Dn;Ps;Hl
Blenniidae	*Lipophrys trigloides* Valenciennes, 1836	Dn
	Parablennius sanguinolentus Pallas, 1811	Dn
	Unidentified species	Dn
Caproidae	*Capros aper* (Linnaeus, 1758)	Dn
Carangidae	*Naucrates ductor* (Linnaeus, 1758)	Dn;Ps;Tl;Hl
	Seriola dumerili (Risso, 1810)	Dn;Ps;Tl; Hl
	Trachurus mediterraneus (Steindachner, 1868)	Dn
	Trachurus picturatus (T. E. Bowdich, 1825)	Dn
	Trachurus trachurus (Linnaeus, 1758)	Dn
Centracanthidae	*Centracanthus cirrus* Rafinesque, 1810	Dn
Centrolophidae	*Schedophilus medusophagus* Cocco,1839	Hl
	Schedophilus ovalis (Cuvier, in Cuv. Val. 1833)	Ps
Coryphaenidae	*Coryphaena hippurus* Linnaeus, 1758	Dn;Ps;Tl
Gadidae	*Gaidropsarus mediterraneus* Linnaeus, 1758	Dn
Lobotidae	*Lobotes surinamensis* (Bloch, 1790)	Ps
Mullidae	*Mullus surmuletus* Linnaeus, 1758	Dn
Mugilidae	Unidentified species	Dn
Nomeidae	*Psenes pellucidus* Lütken,1880	Dn
Scomberosocidae	*Scomberesox saurus* (Walbaum, 1792)	Ps
Scombridae	*Thunnus thynnus* (Linnaeus, 1758)	Ps;Tl
Serranidae	*Polyprion americanus* (Shneider, 1801)	Dn;Ps;Hl
Sparidae	*Diplodus puntazzo* (Gmelin, 1789)	Dn
	Pagellus acarne (Risso,1826)	Dn
	Pagrus pagrus Linnaeus, 1758	Dn
Syngnathidae	*Syngnathus typhle* Linnaeus, 1758	Dn

TABLE 3. – Number (N), size range and month of capture of drifting floating object associated fishes.

Species	N	Size range T L (cm)	Month of capture
Apogon imberbis	4	1.8 - 2.2	10
Balistes carolinensis	17	7.3 - 27.7	7 - 8 - 9 - 10
Blenniidae unidentified	5	1.6 - 2.6	5 - 6 - 7
Capros aper	3	3.3 - 3.5	2
Centracanthus cirrus	2	5.7 - 5.9	2
Coryphaena hippurus	189	3.6 - 72.5	8 - 9 - 10 - 11
Diplodus puntazzo	8	1.5 -2.2	10
Gaidropsarus mediterraneus	4	3.3 - 3.5	5 - 6
Lipophrys trigloides	3	2.0 - 2.4	5
Lobotes surinamensis	1	56.3	9
Mugilidae unidentified	111	1.5 - 2.9	2 - 10 -11
Mullus surmuletus	63	3.7 - 6.5	6 -7
Naucrates ductor	197	2.3 - 37.8	2 - 5 - 7 -8 - 9 - 10 -11
Pagellus acarne	105	1.2 - 4.1	5 - 6 - 10 -11
Parablennius sanguinolentus	5	2.7 - 2.8	5 - 6
Polyprion americanus	7	29.4 - 46.0	5 - 7 - 8 - 9
Psenes pellucidus	1	16.6	11
Scomberesox saurus	27	24.1 - 31.1	10
Schedophilus medusophagus	1	19	6
Schedophilus ovalis	3	44 - 49.6	9 - 10
Seriola dumerili	145	1.3 -31.3	7 - 8 - 9 - 10
Pagrus pagrus	9	2.4 - 2.8	5 – 6 - 7
Syngnathus typhle	4	2.0 - 3.9	10
Thunnus thynnus	34	25.8 - 41.6	9 - 10 - 11
Trachurus spp.	127	1.0 - 11.5	2 - 5 - 6 -7 -8 - 9 -10

RESULTS

Fishes belonging to 18 families were caught and 25 species have been recognised associated with drifting flotsam. In addition, specimens of the families Mugilidae and Blenniidae could not be identified at species level (Table 2).

All the individuals of *Apogon imberbis*, *Capros aper*, *Centracanthus cirrus*, *Diplodus puntazzo*, *Polyprion americanus*, *Balistes carolinensis*,

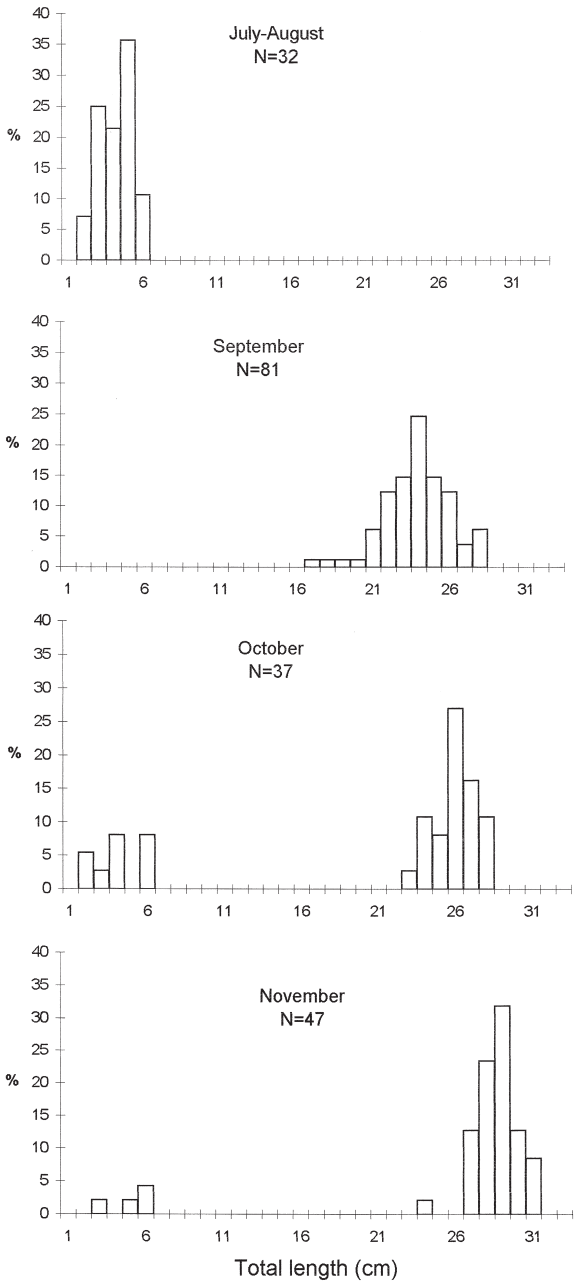

FIG. 2. – Size frequency distributions of *Naucrates ductor* from July to November.

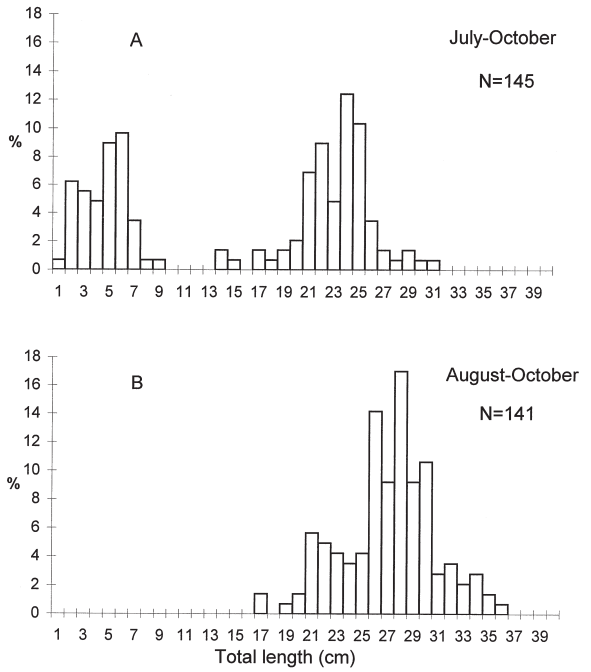

FIG. 3. – Size frequency distributions of *Seriola dumerili*. A) Fishes caught in offshore waters and B) Fishes caught in onshore waters.

Gaidropsarus mediterraneus, *Mullus surmuletus*, *Pagellus acarne*, *Pagrus pagrus*, *Syngnathus typhle*, the mullets and the blennies were presettled forms of benthic fishes, and generally showed narrow size ranges (Table 3). Only individuals of *Balistes carolinensis*, *Naucrates ductor*, *Coryphaena hippurus*, *Scomberesox saurus* and the *Lobotes surinamensis* specimen were adults or mature fishes.

Two fingerlings of *Coryphaena hippurus* (3.6 and 8 cm TL) were collected in neritic waters 0.5 and 3 nautical miles from the west coast of Majorca at 60 and 80 m depth (November 1990 and November 1991). In both cases, the fishes were caught some meters away from drifting objects (about 50 m of a small floating log and about 35 m from a plastic bag respectively) but not directly associated with them. In the capture, the fishes remained absolutely immobile, slightly inclined on one side with the dorsal and anal fins extended.

Regular presence of small (<10 cm TL) *Naucrates ductor* was observed only in two periods of the year: July-August and October-November (Fig. 2).

Scomberesox saurus was caught only in nocturnal purse seine hauls surrounding drifting objects, but was usually observed during the day in the open sea without apparent connection to floating objects.

Ontogenetic changes in the aggregative behaviour of juvenile *Seriola dumerili* were observed, and three stages were detected. Fishes smaller than 10-15 cm TL have a strong affiliation with floating objects, moving very close around them in little schools (normally less than 10 fishes); fishes larger than 10-15 cm TL to approximately 30-35 cm TL continue to be associated with the flotsam, but form larger schools (up to hundreds of fishes) and move considerable distances (50 m or more) from the floating object to hunt actively. These changes are gradual, and the distances and movements

TABLE 4. – Results in number (N) and percentage (%) of the types of materials found as drifting flotsam.

Material	Date 15/07/95 N	%	27/10/95 N	%
Anthropogenic materials	106	83.5	61	63.5
Algae and seaweed	8	6.3	11	11.5
Wood and terrigenous plants	12	9.4	16	16.7
Feathers	1	0.8	5	5.2
Neustonic invertebrates	0	0	3	3.1
TOTAL	127	100	96	100

increase as the fishes grow. Finally, the fishes change their pelagic-oceanic habits for a coastal one. Figure 3 show length-frequency distributions between offshore (A) and littoral fishes (B): the smallest epibentic individuals caught onshore had 17 cm TL and appeared from August, whereas pelagic young were observed during the July-October period.

A high percentage of the drifting objects analysed were artificial (of anthropogenic origin): 83.5 % in July 1995 and 63.5 % in October 1996 (Table 4).

DISCUSSION

Nearly all the captured fishes were juveniles or larval postflexion forms (*sensu* Kendall, Ahlstrom and Moser *in* Blaxter, 1988). From the 25 identified species, 20 were caught with the dip net, (generally the smallest specimens, see Table 1). Most of them (*Apogon imberbis*, *Diplodus puntazzo*, *Lipophrys trigloides*, *Parablennius sanguinolentus*, *Gaidropsarus mediterraneus*, *Mullus surmuletus*, *Pagellus acarne*, *Pgrus pagrus*, *Siyngnatus typhle*, *Capros aper*, *Centracanthus cirrus* and the Mugilidae) had never been described in association with drifting objects in the Mediterranean. The use of a dip net ensures that the species caught have a high level of association with the drifting objects, though it does not mean that these species can only live in the open sea in association with floating objects.

Tough *Coryphaena hippurus* juveniles are very abundant from August to November in neritic and oceanic waters, the catches of dolphinfish larvae and fingerlings are very rare in the Balearic Islands, where Lozano Cabo (1961) reported the capture of 2 specimens (about 10 cm TL) and Alemany and Massuti (1998) collected four early larval stages. The behaviour observed by us and that described by Gibbs and Collette in Palko *et al*. (1982), who observed that very small specimens look like feathers when remaining immobile with the fins extended, indicate that when dolphinfish fingerlings are very young they have a different behaviour from that of the bigger juveniles (>15 cm): they are solitary and do not normally show strong association with flotsam. The rarity of the fingerlings might be due to their "non-aggregative and non-gregarious behaviour", because it contributes to the difficulty of finding the little fishes in the ocean.

Two recruiment episodes were observed in *Naucrates ductor* in the study area: one in July-August and one in October-November (Fig. 2). Many authors suggest that pilotfish juveniles are epipelagic and live associated with floating objects, while the adults live associated with sharks, big rays and other marine animals (Smith-Vaniz, 1986; Bauchot, 1987; Brito, 1991), reaching a maximum total length of 70 cm (Smith Vaniz 1986). However, Wheeler (1978) states that young fishes school in small groups and live associated with great rays, sharks, turtles, sailships or wooden floating objects and that the adults are solitary. In our observations the largest specimens observed never exceeded 37 cm total length and fishes can reach sexual maturity when still aggregated with drifting objects. We believe *Naucrates ductor* join sharks and other big fishes or marine animals as soon as they can, regardless of size: Cousteau and Dumas (1963) observed and photographed a young *N. ductor* of 6-7 cm associated with a *Carcharinus longimanus* in the southwestern Atlantic. The association with sharks or other marine animals may be dependent on their presence or availability. The living hosts tend to remain in favourable environments while drifting objects may arrive at unfavourable sites or may stranded on the coast, where pilotfish are very conspicuous and could succumb to predators (in Ibiza, *N. ductor* are used as live bait to fish greater amberjack in inshore waters, and we have observed large *Lichia amia* hunting pilotfishes nearshore). On the other hand, Smith-Vaniz (1986) thinks that the association with sharks may be related to trophic motives: feeding on scraps and ectoparasites of the hosts.

In our collections *Seriola dumerili* specimens associated with floating objects reached a size of 31.3 cm TL, which approximately coincides with that observed by Massutí and Reñones (1994). The three stages detected in aggregative behaviour are

probably related to changes in feeding habits, as can be inferred from Badalamenti *et al*. (1995), who observed three different size groups related to feeding behaviour of juveniles from 2.5 to 29.7 cm SL. With respect to the appearance of epibenthic juveniles in littoral waters, Lo Bianco (1909) found fishes of similar size to those caught by us (Fig. 3 B) in the same month. Therefore, it seems that in the western Mediterranean the change of offshore pelagic habits for epibenthic ones in littoral waters starts in August and at a size close to 15 cm TL when fishes adquire their final feeding habits.

Scomberesox saurus was only caught in two nocturnal purse seine hauls but it was normally observed during the day in the open sea without apparent connection to floating objects. This may indicate that the catches were fortuitous, but *S. saurus* may have a similar behaviour to *Coryphaena hippurus*, which schools at night under floating objects (Lozano Cabo, 1961). This behaviour may contribute to the fact that *S. saurus* is one of the main preys of *C. hippurus* from Mallorca (Massutí, 1997). Furthermore, association with drifting seaweeds has been mentioned by Safran and Omori (1990) for other species of the family Scomberosocidae, in Japanese waters.

The abundance of most of the fauna associated with floating objects is strongly dependent on season (Roundtree, 1990). Though samples were not taken in all months (see Table 3) our results seem to indicate that the presence of small fishes is related to their spawning season according to Bauchot (1987) or Tortonese (1975); only the data on catches of *Capros aper* and *Centracanthus cirrus* show divergences with their spawning season which are difficult to explain. In addition many benthic or epibenthic species presented only small individuals and showed an extremely restricted size range, so we can infer that they remain associated with floating objects for a short time before they live in their final native environment. In our collections, other fishes reaching relatively large sizes were presettled individuals of bentic fishes (*Poliprion americanus*, *Ba-listes carolinensis*, and *Lobotes surinamensis*); these large sizes are probably determined by the fast growth and the long residence associated with flotsam. Evidence of fast growth exists in aquacultural trials for *P. americanus* and *Balistes carolinensis* (F. Riera, unpublished data). *L. surinamensis* and *B. carolinensis* can remain for long periods associated with flotsam, and some of our observations support this opinion: the *L. surinamensis* specimen was a large post-spawning female, and *B. carolinensis* specimens larger than 20 cm were caught in July, in the spawning season of the species (Tortonese, 1986). It would not be logical to think that settled specimens return to pelagic life.

Although other seas have constant concentrations of drifting floating objects with seaweeds predominating (Parin and Fedoryaco, 1992), drifting objects of anthropogenic origin are more abundant than drift floating algae in the Balearic Islands waters (Table 4). The most common algae observed drifting in our area were *Cystoseira* spp., probably due to their buoyancy and seasonal deciduous fronds (Cabioc'h *et al*., 1992). The presence of these algae is in decline in the Mediterranean (Bellan, 1985) and some species reach very high percentages (80%) of disappearance (Bacescu, 1985); this is also true in the Balearic Islands for *Cymodocea nodosa* and *Zostera nolti*, marine seagrasses, which float when they are cut off. It is thus feasible to consider that anthropogenic objects may partly replace marine floating plants for fishes in the Mediterranean pelagic environment. Kingsford (1992) suggests three consequences of drift algae movement on fish distribution: (1) by moving into an area drift algae may quickly change the distribution of some fish types, especially those that are well dispersed in open water; (2) if fish stay with drift algae for some time, the movements of the algae will determine those of the fish; (3) where algae often drift towards shore, this may result in increased recruitment rates of fish found nearshore as adults. These points may be extrapolated to drift anthropogenic objects and therefore human refuse contributes to the redistribution of fishes.

In short, we conclude: (i) up to now there existed a gap in the knowledge of small fish communities associated with floating objects in the Mediterranean Sea because attention had focused mainly on relatively large specimens (>15 cm aproximately); (ii) the majority of small fish we found (*A. imberbis*, *Diplodus puntazzo*, *Centracanthus cirrus*, *Lipophrys trigloides*, *Parablennius sanguinolentus*, *Gaidropsarus mediterraneus*, *Mullus surmuletus*, *Pegellus acarne*, *Pagrus pagrus*, *Syngnathus typhle*) were benthic species with narrow size ranges that probably remain associated with floating objects for a short time; (iii) floating objects may have a significant impact as a nursery, and consequently on the recruitment and redistribution of pelagic and non-pelagic fishes.

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