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ANCHORED FISH AGGREGATING DEVICES IN AZOREAN WATERS

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SUMMARY

Anchored fish aggregation devices (FADs) were evaluated as fish attractants in the Azores waters to determine if such objects could attract and hold tuna schools and other pelagic fish long enough to be fished profitably. Floating devices were constructed and anchored in nine selected locations around the islands, banks and sea mounts during 1993 and 1994. The results of the commercial activities around the buoys by the local tuna fleets were not encouraging. A small number of species aggregated to the buoys, mainly *Polyprion americanus* (wreckfish), *Coryphaena hippurus* (dolphin fish), *Schedophilus ovalis* (imperial black fish) and *Balistes carolinensis* (grey trigger fish). Technical aspects of the artificial buoys, their behavior, and aggregating effects are described and discussed.

RESUMÉ

Les dispositifs fixes de concentration de poissons (DCP) ont été évalués dans les eaux açoriennes en tant que facteur de concentration de poissons pour déterminer si ces objets peuvent attirer et retenir des bancs de thons et d'autres pélagiques suffisamment longtemps pour pouvoir les pêcher de façon rentable. En 1993 et 1994, des dispositifs flottants ont été construits et ancrés à neuf endroits différents autour des îles, des bancs et des guyots. Le résultat des activités commerciales des flottilles thonières locales autour de ces radeaux n'a pas été encourageant. Un petit nombre d'espèces se sont fixées autour des radeaux, notamment *Polyprion americanus* (cernier atlantique), *Coryphaena hippurus* (coryphène commune), *Schedophilus ovalis* et *Balistes carolinensis* (baliste). Les aspects techniques des objets flottants artificiels, leur fonctionnement et leur effet agrégatif sont décrits et commentés.

RESUMEN

Se evaluaron en aguas de Azores los dispositivos anclados de agregación de peces (FAD) como atrayentes de peces para determinar si tales objetos podían atraer y mantener cardúmenes de túnidos y otros peces pelágicos el tiempo suficiente para ser capturados con provecho. Se construyeron y anclaron dispositivos flotantes en nueve lugares seleccionados en torno a las islas, bancos y montes marinos durante 1993 y 1994. Los resultados de las actividades comerciales en torno a las boyas por las flotas locales atuneras no resultaron alentadoras. Un pequeño número de especies se agregaron a las boyas, principalmente *Polyprion americanus* (cherne), *Coryphaena hippurus* (dorado), *Schedophilus ovalis, y Balistes carolinensis* (pez ballesta). Se describen y discuten los aspectos técnicos de las boyas artificiales, su comportamiento y efectos de agregación.

I - INTRODUCTION

The log books from the Azorean tuna fishery refer to observation of two types of tuna school aggregation: "achados" and "pintados". The "achados" are floating objects, usually coming from commercial navigation (boats or parts of boats, pallets, planks, cable drums, ropes, plastic and metal drums, rafts, fishing gears and buoys) and some plant material (drifting trees, canes and other debris). Another type of objects are research buoys and dead whales. The aggregation of tuna schools with "pintados" (whale-shark, *Rhincodon typus*) is also often observed.

The catches near or beneath these drifting objects, mainly bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*), made in pure or mixed schools, represented about 14% of the total catch of tuna in the Azores. At the present, using the information given by scientists, the fishery is trying to explore the schools of tunas associated to the boat during some days, using the fishing procedure described for Senegal and Canary Islands baitboats (Fonteneau, 1993; Ariz *et al*, 1994).

According to experiments made in Japan Sea, Philippines, Hawaii and other areas in the world and with practical application to the fishery, the same pattern of aggregation seems to occur when anchored or free floating artificial devices are used, known as FAD's, Fish Aggregating Devices (Gerakas, 1979; Kihara, 1981; Ugolini & Robert, 1982; Matsumoto *et al*, 1981; Shomura & Matsumoto, 1982; Fonteneau, 1992; Ariz *et al*, 1992).

Why do fish buoys aggregate fish? Although scientists have offered a number of hypotheses on this subject (providing protection from predators, concentrating food supply, acting as cleaning station or simply serving as a point of reference in open ocean environment) there is not a precise explanation for the ecological significance of anchored and drifting objects to pelagic fish (Gooding & Magnuson, 1967; Hunter & Mitchell; 1968; Brocks, 1985; Holland *et al*, 1990).

Knowing the benefits for the fisheries and taking advantage of this behavioural characteristics of such pelagic fishes, also observed of the Azorean waters, the Department of Oceanography and Fisheries of the University of the Azores, began experiments with anchored buoys in July 1993. During this first phase the objective of the program has been to determine if the use of such anchored floating objects could be adapted to local conditions in the Azorean waters. Floating devices were constructed and anchored in a few selected locations and observations of such objects could attract and hold tuna schools and other pelagic fishes long enough for fisherman to fish them profitably was analysed from the information received by the local tuna fleet.

This paper describes the technical aspects of the devices used and results of the fleet behaviour and effects on tuna aggregation.

II - MATERIAL AND METHODS

1 - Type of devices

Initially two types of devices were constructed: anchored (Fig. 1) and drifting devices (Fig. 2). The drifting devices were not used due to the problems associated with security of navigation and limitations to developed a monitoring scheme of such devices.

A catenary curve mooring system was adopted for the anchored devices (Fig. 1), (Gates, 1992). The mooring consisted of the upper chain (15m) connected directly to the buoy, sinking rope (nylon), buoyant rope (polypro), and a section of chain (15m) connected to the anchor (900 kg). The different components of the mooring were connected with a swivel to prevent twists. The upper chain-nylon rope combination hung straight down below the buoy and protects the upper mooring and the catenary curve from damage by fishing boats or passing ships. To prevent the lower mooring rope from being cut or abraded by rocks along seabed the bottom chain is maintained 3 m off the seabed, using an extra buoyancy supplied by pressure resistance floats. In addition this scheme prevents the anchor from being displaced because the bottom chain works like shock absorber of the forces that reaches the anchor. The rope-lengths and the additional buoyancy needed depends on the depths of the local habitat. Table 1 summarises the information of the characteristics of the mooring system adopted for each local.

Nine of these devices were constructed, seven using a spherical steel buoy with 1.5m of diameter, one with a spherical plastic buoy of 1m of diameter and one with a conical PVC buoy. (Fig. 3). The buoys, of yellow colour according the international standards requirements, were equipped with a navigational warning light visible at 1 mile and with a radar reflector. Each buoy, until 30 m depth, was equipped with different kinds of appendices (tires, nylon and plastic ropes, plastic flags, etc.) for best attractive effect.

2 - Location of the buoys

The areas for mooring the buoys were first selected based on the analyses of the cartography of the catches of the local fleet, as the areas of occurrence of tuna. Within each area, different depth, distance of the coast, near the banks and sea mounts were chosen. With this methodology buoys 1, 2 and 8 were placed in areas near the coast, used by the fleet and in relatively calm waters, buoy 9 near the coast but fully exposed to the currents and winds, buoy 5 near a bank (Princess Alice), buoy 4 near of a seamount, buoy 3 and 6 in an area of open sea, buoys 7 in an area near the coast but not frequently used by the fleet (Fig. 4).

3 - Installation and monitoring buoys

Three buoys (3, 6 and 7) were initially moored in the central islands on July 1993 and all the others in April of 1994. The simplest method was used in mooring the buoys. The buoys was first set on the water at the selected site, the anchor line was payed out as the vessel moved slowly in a circular path around the buoy, and the anchor was released in a free fall to the bottom. Monitoring and maintenance of the buoys were initially scheduled on a bimonthly basis. This schedule could not be made, however, due to prolonged periods of rough sea conditions, loss of buoys and limitations associated with the obligations of the research vessel. During each visit, made in the morning, observation of the presence of bird flocks and fish schools near the buoy and in the area immediately around were made and recorded. Underwater observation were made in buoys 3, 5, 6 and 9.

Monitoring of fish catch from commercial tuna pole-and-line boats visiting the buoys were made through log books supplied to each boat and from interviews with skippers.

III - RESULTS

1 - Buoy performance

The buoys performed as expected in attracting and holding some marketable fish species, although in a very small numbers, and adapted to the condition of the Azorean waters, with a life span between 4 and 15 months (Table 2). Buoys of oriental group (1,2 and 8) lasted about 5 months and were cut by longline boats. Buoys 3 and 6 lasted about 5 months before they broke free and 15 and 11 months respectively before broke for the second time. From the nine initially buoys, 6 were lost, 2 were recovered and only one (buoy 3) remain in the position. Despite these losses, the buoys at all sites remains in position long enough to demonstrate that they performed well to the condition of the Azorean waters. Problems are associated with longline fishing operations and with the light which operated continuously and sometimes the lights and radar reflectors were removed.

2 - Monitoring visits

Visits to the buoys were interrupted at various times, either because of sea conditions or loss of buoys (Table 2). A total of twelve visits were made at the total, and only the buoys of the oriental group (1, 2 and 8) were not visited. In all visits were observed schools of fish aggregated to the FAD´s, although in a small number (10 to 100 fishes). The species observed in each buoy were the same, and all of them of a great marketable value: Wreckfish (*Polyprion americanus*), Imperial blackfish (*Schedophilus ovalis*), Dolphin fish (*Coryphaena hippurus*), Grey trigger fish (*Balistes carolinensis*), Oceanic horse mackerel (*Trachurus picturatus*), Amberjack (*Seriola spp.*) and Pilot fish (*Naucrates ductor*). The first four species were observed in all visits, in number of 2 to 5 fishes for the Wreckfish, and 10 to 100 fishes for the other three species. However, tuna schools were not observed around the buoys or in the vicinity of 3 miles.

3 - Pole-and-line fishing

Because the first three buoys were deployed at the middle of the tuna season, July 1993, and consequently the fishermen were reluctant to leave their traditional fishing grounds, the visits of the buoys in 1993 was minimal, although all the fleet had visited the buoys at least once and without significant results. The number of visits improved in the beginning of the season in 1994, with all the fleet visiting the buoys, but tuna catches were not reported. Only in June catches of bigeye (*Thunnus obesus*), 10 ton, and skyjack (*Katsuwonus pelamis*), 5 ton, aggregated to the buoys 3 and 4 and later in August a catch of 5 tons of skyjack (*K. pelamis*), aggregated to the buoy 1, were reported. Interviews to the fishermen reveal that catches of Wreckfish (*P. americanus*), Imperial blackfish (*S. ovalis*), Dolphin fish (*C. hippurus*), Grey trigger fish (*B. carolinensis*), Oceanic horse mackerel (*T. picturatus*) and Amberjack (*Seriola spp.*) were made periodically in small number, but tuna schools were not observed. Artesanal fisherman also caught the same species but these catches were not reported. The usual fishing routine followed by baitboats was not altered because the FAD´s.

The interviews to the fishermen and the analysis of the data from the log books, which covered approximately 40% of the fleet (Fig. 5, 6 and 7) seems to show that the anchored buoys didn't performed as expected in attracting and holding tuna schools. Although other pelagic species are attracted successfully the fishermen are reluctant to report the catches.

IV - DISCUSSION AND CONCLUSION

The results confirm the expected performance of the buoys related to the conditions of the Azorean waters. However, the sites selected for the buoys seems to be too far way for monitoring and maintenance purposes, creating difficulties in the case of losses.

The evaluation of the aggregation effects based on the information received by the fleet can not be done with precision because the fishermen just reported the visits with successful catch of tuna, which occur only during three occasions. The catch of the other species are not recorded in the log books, but personal information from the skippers seems to show that the catch of Dolphin fish (*C. hippurus*), Wreckfish (*P. americanus*) and Imperial blackfish (*S. ovalis*) are significant, since catch of this species were made in almost all visits. Catch of baitfish (200 kg), oceanic horse mackerel (*T. picturatus*), made in the buoys was reported only by one baitboat, although schools of this specie were observed in several occasions at FAD´s.

The analysis of the logbooks and interviews to the skippers supported the conclusion that the visits were made occasional and without any strategy. The fleet doesn't modify the traditional pattern of operation even after the successful catches of tuna reported on three occasions. No skipper adopted a planning schedule of visits to the buoys, trying to visit them routinely at different periods of the day as the suggestions made by scientists. Beside the scepticism of the skippers related to the effects of the anchor devices in attracting and holding tunas, there is not a comprehensive explanation for this behaviour, specially during the year of 1994 characterised by a reduction of about 50% of the catches of bigeye tuna. If this reduction was due to the real variation of the abundance of this specie, as a consequence of some environmental anomaly, it is possible that this fact influenced the results of the experiment. Observations made during the visits of monitoring, although not conclusive, confirm that the tuna are not attracted frequently to the FAD's. These results could be related with several aspects as the period of the day that the visit was made or even with the sites where the buoys were placed.

Although results are not conclusive related to the aggregating effects of tuna schools, the devices aggregating successfully a number of other marketable species: Wreckfish (*P. americanus*), Imperial blackfish (*S. ovalis*), Dolphin fish (*C. hippurus*) and Grey trigger fish (*B. carolinensis*). This species are observed and caught from May to September and effort must be made to get information of the catch in the future. Tuna species, mainly skipjack (*K. pelamis*) and bigeye (*T. obesus*), were captured only in three occasions at different buoys, but the skippers reveal that sometimes catches were made in vicinity of the buoys located at the traditional fishing area, but they don't report these catches as associated to the device. The albacore (*T. alalunga*) were captured too in the vicinity of the FAD's but the fishermen believed that this species doesn't aggregate to the FAD's and it is difficult to have conclusions because they were caught in areas of traditional operation of the fleet.

The impact of the FAD's in the tuna fishery seems to be poor but this conclusion must be interpreted with some caution because one year and half for this kind of experiment are not sufficient, and fishermen do not follow an adequate strategy of fishing with the FAD's. They are reluctant too in reporting the visits and catches, and the available information with quality has only covered 40% of the total fleet.

In a general way the fisherman are sceptical about the aggregating effects of the anchored devices and request often experiments with drifting devices. Although constructed these devices were not placed because legal and administrative problems related to the security of the commercial navigation and due the difficulties in monitoring this kind of devices.

For the second phase of the project we suggest to place buoys only in the central group, in sites near the coast and with a monitoring scheme on a monthly basis. This procedure will permit us to study with precision the species aggregated, the evolution of the aggregation, times of residence, etc. The drifting buoys must be placed and monitored by satellite.

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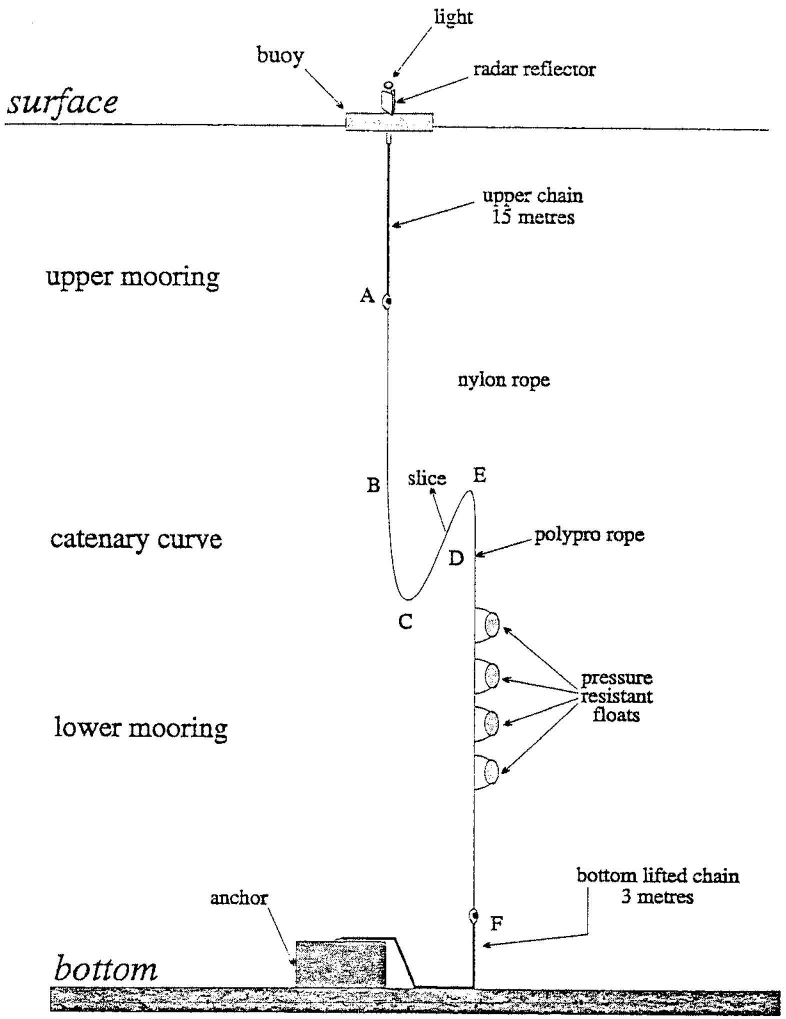


Figure 1 - Type of mooring system used for anchored FAD'S in Azores.
(Adapted from Gates, 1992)

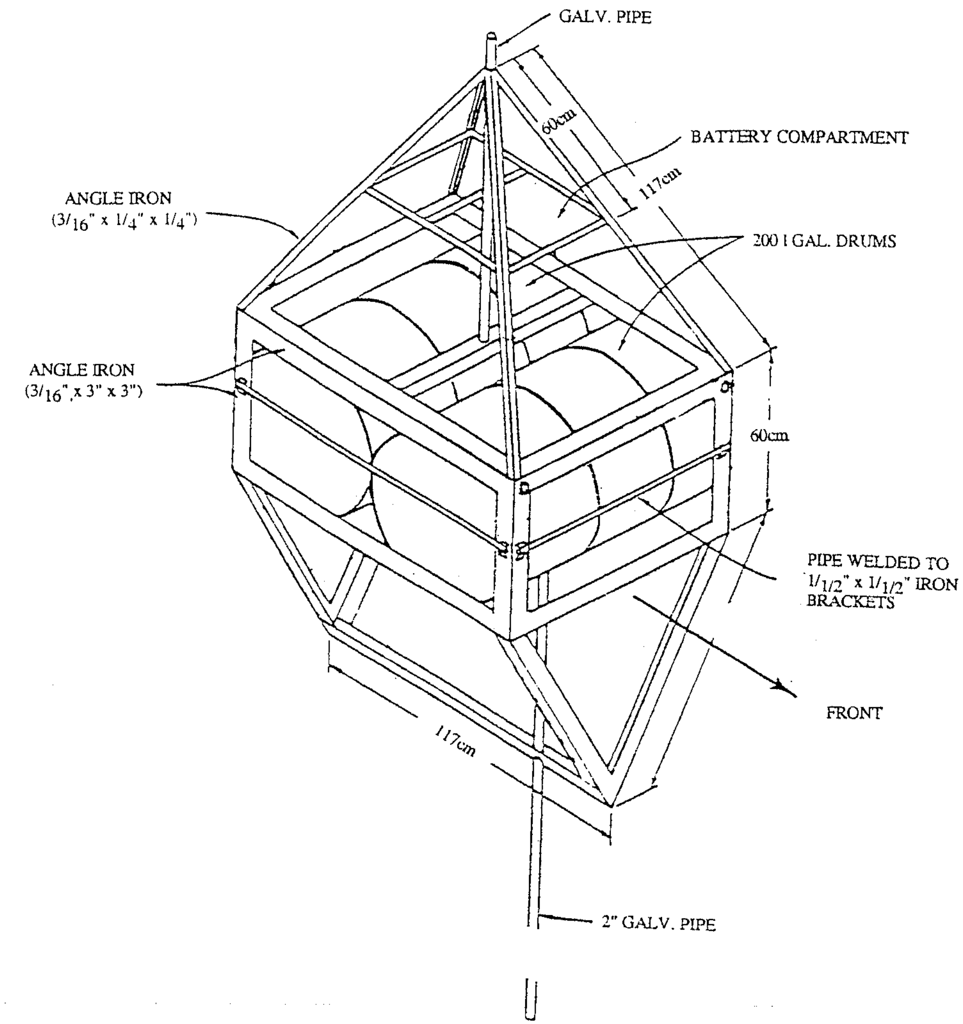
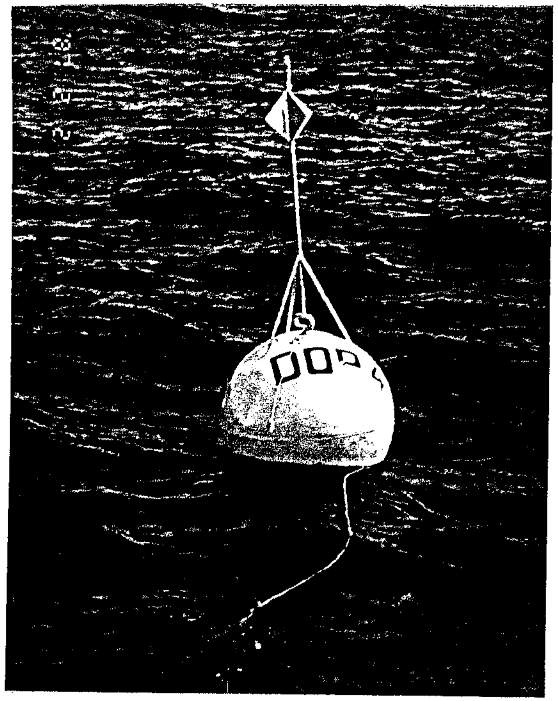


Figure 2 - Details of the drifting buoy (adapted from Matsumoto *et al.* 1981).



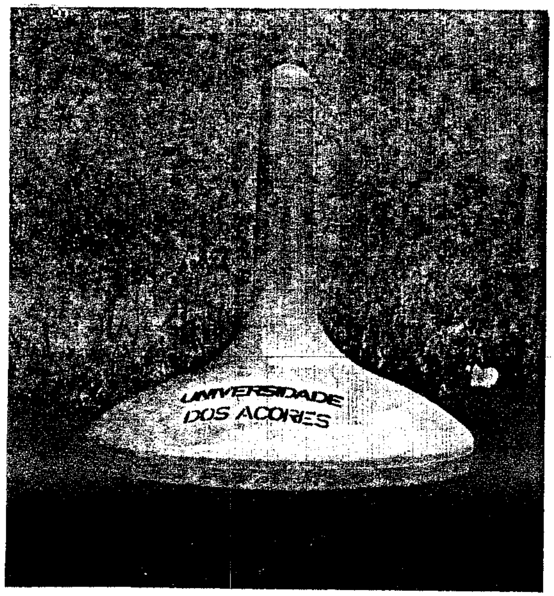


Figure 3 - Buoy type used in Azorean FAD's.

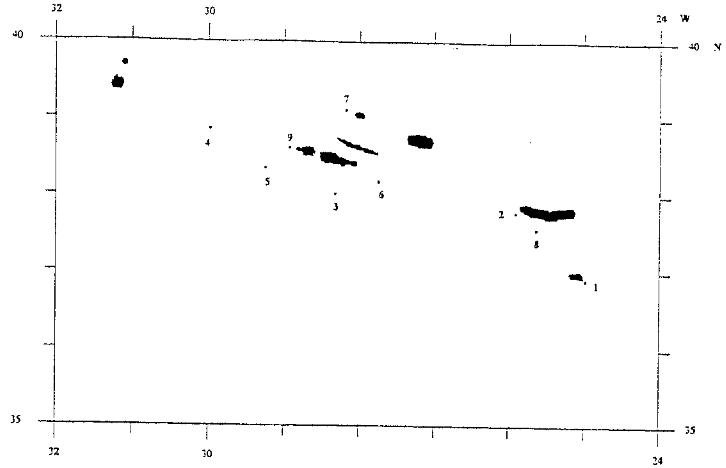


Figure 4 - Location of the FAD's in Azores.

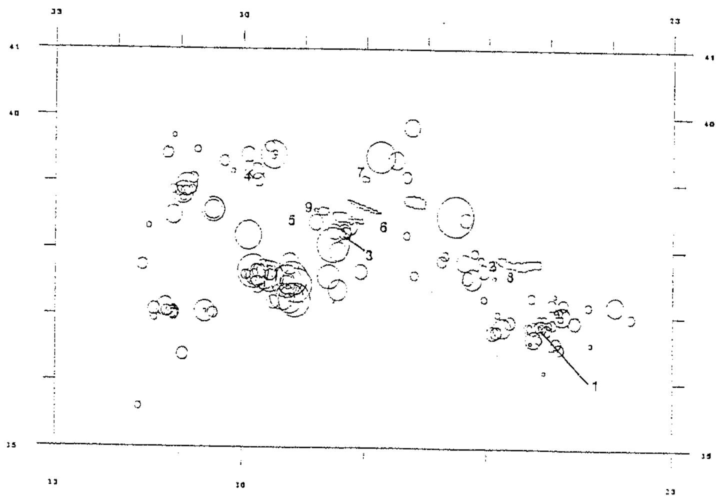


Figure 5 - Distribution of catches of bigeye tuna (*Thunnus obesus*) by Azorean baitboats during 1994

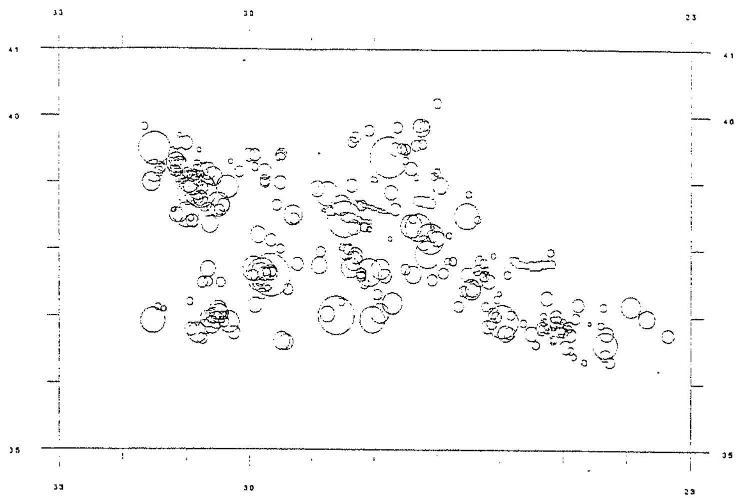


Figure 6 - Distribution of catches of skipjack (*K. pelamis*) by Azorean baitboats during 1994

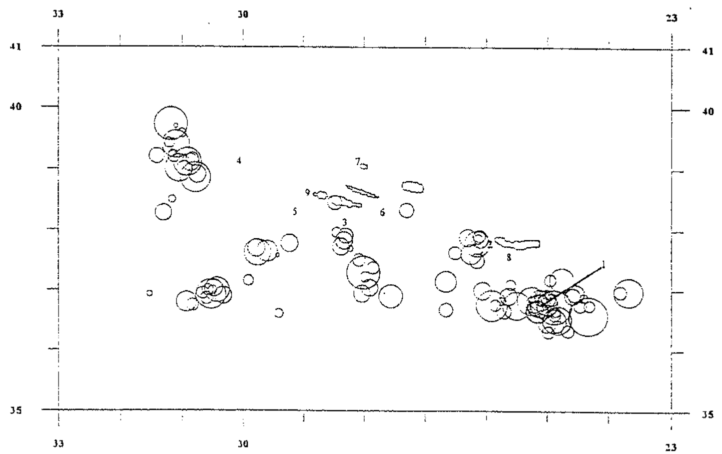


Figure 7 - Distribution of catches of albacore (*T. alalunga*) by Azorean baitboats during 1994

Buoy n°	POSITION DEPTH (m)	LAT. (N)	LONG. (W)	CHARACTERISTICS (see Fig. 1) CHAIN (m)	AB (m)	BCD (m)	DE (m)	EF (m)	N° of float	TOTAL ROPES NYLON (m)	POLIP (m)	TOTAL (m)
1	965	36.53	24.59	15	250	160	40	535	5	410	575	985
2	500	37.47	25.55	15	200	100	25	285	7	300	310	610
3	1550	38.01	28.20	15	200	307	68	1285	6	507	1353	1860
4	953	38.52	29.59	15	250	200	50	735	5	450	785	1235
5	1016	38.21	29.15	15	250	200	50	735	5	450	785	1235
6	1011	38.10	27.44	15	250	200	50	735	5	450	785	1235
7	561	39.07	28.11	15	200	100	25	285	7	300	310	610
8	987	37.34	25.38	15	250	200	50	735	5	450	785	1235
9	1570	38.37	28.56	15	200	307	68	1285	6	507	1353	1860

Table 1 - Characteristics of the moorings

Year	1993						1994												1995					
Month	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Buoy																								
1										*	*	*	*	*	?									
2										*	*	*	*	?										
3	*	V	*	*	*	*	*	*	+	V	*	*	*	V	*	*	*	*	*	*	*	*	*	V
4										*	*	*	*	V	*	*	*	*	?					
5										*	*	*	V	*	*	+								
6	*	*	+	*	*	*	*	*	*	V	*	*	*	V	+									
7	*	*	V	*	*	*	*	*	*	*	*	*	V	?										
8										*	*	*	*	*	+									
9									*	*	V	*	*	V	*	*	*	?						

* Life span + Broke ? Lost V Visits

Table 2.- Azorean FAD's installation, replacement and visits schedule.