FISH AGGREGATING DEVICES IN FRENCH POLYNESIA

BY

JACQUES CHABANNE[1]

The use of FADs for the development of tuna fishing in French Polynesia was contemplated in late 70's (Marcille. 1979). The first deployment of FADs was undertaken soon after by the organization in charge of projects for fishery development (Ugolini and Robert, 1982).

In the early stages of the FAD project, the objectives of a rather general nature, were more specifically directed to developing surface tuna fishing, i.e. skipjack and yellowfin fishing. The immediate goal was to assist the artisanal skipjack fishery which was experiencing economic difficulties. In the long run, the aim is to promote a more industrial type of exploitation, calling for fishing techniques having a high degree of efficiency. However, after a few years, one is able to observe that a gap exists between the initial goals and the actual use of FADs. Concerning surface fishing, spin-offs have remained limited (artisanal skipjack fishery) or non-existent (fishery development). On the other hand, the artisanal handline fishery for deep swimming tunas has proved to be the main user of FADs.

The difficulties encountered in attaining the expected goals, particularly in fishery development, became apparent from the very beginning of the project. They resulted from insufficient knowledge of the manner in which FADs work and, more specifically, their efficiency in aggregating fish. Besides, technical problems concerning their durability at sea occurred in the case of the first FADs. Both in order to solve technological issues and to determine the actual possibilities of FADs for tuna fishing in French Polynesia, a research and development programme has been undertaken (Anon. 1985).

1. GLOBAL FISHERY CONTEXT

1.1 Description of region and resources

The Exclusive Economic Zone (EEZ) of French Polynesia covers a very vast expanse of ocean of nearly 5,000,000 km^2 in the Central South Pacific between 5 and 30°S (Fig. 1). The land mass comprises about a hundred volcanic high islands and atolls very limited in surface area, Tahiti, the largest, measuring approximately 1,000 km^2. These islands are divided into four groups: the Society, Marquesas, Tuamotu-Gambier and Austral Archipelagoes. Apart from lagoon area, there is no outside continental shelf and the slope of the island edges is very steep, right from the shoreline.

Tuna resources include four main species: skipjack *(Katsuwonus pelamis)*, yellowfin *(Thunnus albacares)*, bigeye *(Thunnus obesus)* and albacore *(Thunnus alalunga)*. The first two speices are the most abundant and make up the bulk of the surface population. The last two are found exclusively in the sub-surface area. The whole EEZ is inhabited by these species but their distribution is not homogeneous.

The surface sub-population is concentrated in the Marquesas and Society Archipelagoes and northward 22°S in the Tuamotu Islands (Fig. 1). Schools stay near coasts, especially in Society and Tuamotu. The other areas of the EEZ have very poor resources, particularly the open-sea areas where schools are found only occasionaly. The tuna biomass within that major area was assessed as being

[1] Centre ORSTOM de Tahiti.

approximately 90,000 tons by means of aerial surveys (Petit and Kulbicki, 1983). The Marquesas Archipelago is the richest with 60% of the biomass, while representing 35% of the surface area. Skipjack is more abundant than yellowfin, 2/3 – 1/3 as an average, but there are slight regional differences and yellowfin is proportionally more abundant in the Marquesas. Clear-cut seasonal variations are observed all over the EEZ. Resources are more abundant during the warm season, i.e. from November–December to May–June.

The deep water sub-population is more evenly distributed in the whole EEZ. However, as is the case for the surface sub-population, the Marquesas region is richer. The proportion of species varies with latitude. Northward 12°S, bigeye and yellowfin widely outnumber albacore, while the reverse is true south of that latitude.

1.2 Fisheries

The level of harvesting is very uneven according to the population part concerned.

– Deep tunas are harvested by the Japanese and Korean long-line fishing fleets. The former focusing on the bigeye, concentrates on the Marquesas Archipelago. The latter, many boats of which search specifically for albacore, is interested in the entire EEZ. Catches over the last six years are shown in Table 1.

Beside the foreign industrial fisheries, there is a local artisanal fishery, mainly in the Marquesas and the Society Islands. Fishing is coastal and carried out using canoes or 18' speed-boats type boats called "poti-marara". The fishing gear is a deep hand-line. A few larger boats sometimes using a mini long-line, also fish deep swimming tunas. Fishermen are spread all along the coast of the islands and due to this, collection of catch data is difficult. Catches from 1986 to 1988, for which a reasonable estimate can be put forward, are given in Table 1. This fishery is presently the most concerned with the FADs.

– Surface tunas are harvested by the artisanal skipjack fishery, restricted to the Society Archipelago (Fig. 1). Fishing boats are small size launches, about 12m long, with two or three-man crew. The gear used is pole-and-line, but mother-or-pearl lures are substituted for bait. In general, boats depart for fishing early in the morning and return in the mid-afternoon. Catches from 1983 to 1988 are shown in Table 1. Apart from this skipjack fishery, surface fish are caught with troll by the poti-marara fishery and sports and game fishermen, which is neglible in terms of the quantities caught.

1.3 State of stocks – Goals of the fishery policy

The surface tuna resources in French Polynesia are largely underexploited. In the two archipelagoes where they are found, the Tuamotu and the Marquesas (area of maximum abundance), there is no fishing. The exploitation rate of the Society Islands stock by the skipjack fishery (about 1,500 tons year catch) is far below the local stock potential, the biomass of which is estimated between 10,000 and 15,000 tons (Kleiber *et. al.*, 1983, Petit and Kulbicki, 1983). In a more global way, the local stock is included in a stock of the Central Pacific region which is in a healthy state, as the development of tuna fishing in the neighbouring countries is still limited.

In such a situation of underfished resources, the general objectives of the fishery policy can be easily defined, i.e.: development of resource exploitation. However, difficulties appear during the following stage. As in most countries, the usual conflict between artisanal and industrial fishing comes up even if the latter is still in the project state.

Nevertheless, the main obstacle in developing the tuna fisheries is an economic one. The production cost in the artisanal fishery is high. Prospects for industrial fishing are not good as the existing natural conditions for pole-and-line or purse-seining are not favourable. The introduction of FADs is one of the solutions meant to improve fishing yield and solve the economic problem.

2. DESCRIPTION OF THE ARTIFICIAL STRUCTURE

Structures utilized for aggregating fish are of the anchored-buoy type. Several models of buoys, made of various kinds of materials (wood, polyester, iron) were tested. The mooring line has also evolved since the outset of the project to increase the FAD life (Depoutot, 1987). The type presently in use is represented in Fig. 2. It provides the best nautical qualities and can be deployed with a small sized boat. In order to make this operation easier, tests of polymorphic buoys are now being carried out. The cost of this type of FAD is rather high but one of the reasons for this is the requirement imposed by the Maritime Authorities to have navigational lights. Besides, the generally high mooring depths also increase the cost, all the more so since the high basic price leads to seeking the longest life, i.e. by making use of high quality materials.

Since the start of the project (1981), 113 FADs have been deployed. Annual numbers are fairly variable. They clearly increase in 1989 during which year some forty FADs were deployed, the same number being planned for 1990. The main data on the FADs are shown in Table 2. The Society Archipelago is the area where most of the devices have been deployed (70%), particularly in Tahiti (Windward Islands) with 52%. These figures reflect the geographical distribution, both the population and the fishermen. The mooring distance from the coast is higher in the Society Islands as a certain number of FADs were laid at some distance from the coast in order to restrict poti-marara fishing and favour skipjack boat fishing. The life of a FAD is extremely variable and runs from a few days to over four years (1,643 days maximum). As an average, their life-span has almost doubled since the start of the project. However, it is now decreasing due to the general use of floats to support the lines. Such a device brings lines nearer to the buoy but in the process, it happens often that some hooks get caught in the mooring rope which as a result deteriorates and becomes fragile.

By October 1989, 35 FADs are still in operation, most of them having been moored during the year. The oldest is over two years old (880 days) and two other two years old.

3. SOCIO-ECONOMIC CONTEXT

Assessing the socio-economic aspects of an activity pertaining to an un-structured sector is usually difficult. This is due to two reasons. The first is the widespread of the fishermen population, making data collection a very costly operation. The second is the lack of accuracy of most of the economic data due to the small size of operational units and the dispersed nature of the marketing, often conducted on a family basis. The knowledge obtained is therefore both general and superficial.

FAD users may be classified by type of fishery.

– **Skipjack fishery.** Skipjack fishermen are professional fishermen. Having formed a union, they are approximately 300 in number. Skipjack fishing is closely related to the size of the population and accounts for 75% of the activity for Tahiti alone. The fish is usually caught during daytime and sold fresh on the wharf and in local markets either through family sellers or fish merchants. The surplus may be sold on road-sides or to a recently established fish trading company. The fishermen's income is not very high and various aids are granted, mainly a fuel subsidy.

– **Poti-marara fishery.** This activity involves some three hundred professional fishermen, half of whom are based in Tahiti and grouped together in several unions. Their use of several fishing techniques (harpoon, trolling, hand line..) generates greater profits by adapting methods to optimum conditions. With the increase in the number of FADs and the facilities they afford, it seems that a larger share of their activity is directed to handline fishing. Catches are sold in the markets, on road sides and directly to restaurants and hotels. The fishermen's incomes appear to be reasonably good.

Next to the professional category, are the occasional fishermen. In most cases, they have another job and fishing provides a more or less important supplementary income. The numbers in this category fluctuate to some extent.

– **Sports and game fishing.** The FADs located in the vicinity of the populated area are also visited by sport fishermen searching for marlin and large yellowfin which are found frequently enough.

– **Food fishery.** This is the main use of FADs for distant and thinly populated islands.

FADs are located in the high seas, in traditionally open areas and they belong to the relevant government department. Therefore there is no special title of ownership or exploitation. However, they are almost all moored at the request of municipal authorities or fishermen from a village and are usually anchored in the vicinity of a village. Consequently, there is a tendency on the part of the requesting community to consider the device as their own.

The FAD project was initially aimed at assisting the skipjack fishery. The early devices, solely used by skipjack fishermen served their purpose (Ugolini and Robert, 1982). Subsequently, the poti-marara fishermen began operating near the FADs and drove skipjack fishermen away, firstly, by interfering with the latter's navigation and secondly because skipjack fishermen claim that poti-marara fishing brings about a change in the behaviour of fish which they are no longer able to catch. They have virtually stopped using FADs where poti-marara fishermen are operating. To compensate for this a number of FADs were positioned further out at sea and due to the distance skipjack fishing boats alone have practical access to them. Over the last few years, however, during the slack season for surface fishing, some skipjack fishing boats switched to line fishing in the vicinity of FADs used by poti-marara.

So far, no major conflict has occured due to the FADs as they have not brought about really radical changes in Polynesian fishing activity. In particular, there has been neither a decrease in the sale price of fish nor difficulties in marketing catches. FADs have been positive for some people while they have not proved negative to others.

4. ASSESSMENT OF BIOLOGICAL IMPACT

The FAD phenomenon corresponds to a biological process affecting the behaviour of some species of fish. The result is an aggregation of the sensitive species, therefore a positive change in their catchability. Most of the time, this factor was used empirically to improve the production of a given fishery. It is also one of the objectives of the FAD project in French Polynesia. But the project includes another objective, i.e. developing a new activity. This is obviously more difficult to achieve and requires a specific knowledge of the operation and efficiency of FADs.

4.1 FAD impact in the fisheries

As the scattered nature of fishing activities requires considerable effort to collect data, which was not required upto now for fisheries management, detailed knowledge is limited to a few locations. The influence of the introduction of FADs in fisheries is consequently assessed only on a rough basis.

– **The poti-marara fishery.** This fishery is presently the main user of FADs, particularly in Tahiti, but the results on the overall production are not known and are most likely to be limited. Thus, the production from three landing centres on Tahiti Island were assessed in 1987 and 1988 (SMA, 1989). The number of fishermen has not changed and catches do not reveal any trend. The results for 1989, which saw a definite increase in the number of FADs, are not yet available.

The main species caught near FADs are yellowfin tuna (mainly large size fishes) and albacore. These two species are caught with deep handlines, under 100m depth. In surface fishing (trolling or harpoon), catches include skipjack, small yellowfins and dolphin fish *(Coryphaena hippurus).*

– **The skipjack fishery.** The activities of the skipjack fishing boats based in Papeete harbour (approximately 50% of the fishing fleet) have been regularly surveyed for some ten years. Daily sampling is carried out, catches evaluated, identified and measured (Chabanne and Ugolini, 1986), fishing spots are noted as well as circumstances, i.e. presence of bait fishes, fishing under logs, fishing around FADs. There is obviously some degree of vagueness since most of the time fishermen note only the dominant features.

The vists to FADs by skipjack fishing boats, significantly less than 10% of the total fishing effort, is far too limited to have any effect on the overall production.

Depoutot (1987) calculates the CPUE achieved by the skipjack fishermen around the FADs during 1981–1986. It is of 50 fish per day. Over the same period, the CPUE of skipjack fishermen not using FADs is 41.5 fish per day, i.e. a difference of about 20% in favour of FADs. The catch composition is almost identical, yellowfin only being slightly more abundant in FADs catches.

Moreover, it should be noted that:

– the CPUE near FADs shows a positive relationship with the abundance of tunas in the surrounding area.

– seasonal variations are also recorded in FADs catch, as in the general catch.

The length composition of catches around FADs has its own structure, as shown in Figs. 3 and 4, in which it is compared to catches taken under other conditions. It may particularly be observed that the ratio of smaller fish is lower in FAD catches, especially for yellowfin, than in log catches. Additionally, large fish, not found in log catches, are substantially represented in FAD catches.

4.2 Operation and efficiency of FADs

In terms of production, FADs are largely underutilized by the artisanal fishery as the efficiency of its fishing methods is limited. A priori, it may be thought that using more efficient methods will enable fishermen to derive greater benefit from fish concentrations induced by FADs. The issue is to confirm this hypothesis. For this purpose, the direct method is to carry out experimental surveys while using the concerned fishing technique. Such a solution is generally costly and, in the case of French Polynesia, hard to achieve. Another approach was therefore chosen. The study of the efficieny of FADs and of trends in aggregation in the short and medium term was dealt with by resorting to the methods of acoustic tele-measurement. The fish behaviour was also studied.

4.2.1 Materials and methods

The acoustic surveys provide an overall knowledge of aggregations existing near a FAD. They are description and measurement tools: echo sounding for detecting fish and describing aggregations, echo integration for quantifying them. When applicable to the phenomenon under study, they offer the advantage of eliminating the catchability problems related to fishing surveys. Consequently, the unit of measurement remains stable in time and space. However, their disadvantage is that they do not allow for any identification to be made of the aggregation components.

The basic equipment includes a portable type scientific echo sounder, a digital acoustic tape recorder and a digital integrator.

Survey around a FAD follows the diagram shown in Fig. 5. The distance covered starting from the buoy is usually 0.3 nautical mile but may be raised depending on fish distribution. The signals received are recorded. They are reread in the laboratory for analysis and processing by the integrator.

In order to study individual fish behaviour, fish tracking is carried out by means of ultrasonic telemetry (Cayré and Chabanne, 1986).

4.2.2 Preliminary results

The period of preliminary studies lasted from mid-1985 to mid-1986. Several FADs were surveyed on a more or less regular basis. The outlines of the results are given below.

– **Area of aggregation.** An area centered on the FAD may be defined in which fish is found (Fig. 5). It does not form a regular-shaped circle around the FAD but is more extended in some directions. The surface area is variable according to the individual FAD and for the same FAD during the course of the day (it decreases at night). In this aggregation area, the fish do not form a continuous school and their distribution is not homogeneous. In general, their density increases closer to the FAD. Moreover, density is often greater in some quadrants.

– **The species composition.** The main species forming the aggregations are skipjack and yellowfin Skipjack aggregate in shifting schools mainly between 50 and 100m in the daytime and between 10 and 80m at night. Yellowfin seems to be less mobile than skipjack. The young fish stay between 50 and 140m in the daytime and 30 and 110m at night. The older fish are found deeper and are caught up to more than 200m. A third species, the albacore tuna, is also found in deep waters. It seems to be more abundant than old yellowfin, at least for a part of the year. On the surface, dolphin fish are often found. Sharks are frequent and may abound around some FADs. Marlins are found occasionally.

– **Description and assessment of aggregations.** A few major trends can be noted from the survey data.

Variations between FADs. Significant discrepancies appear in integrated values from one FAD to another, confirming the variability in efficiency as noted by fishermen. The ratio observed runs from 1 to 100 between the "poorest" and the "richest" FAD, the latter located in the unexploited area of Tuamotu Islands. Another difference appears in the depth of concentration. For two FADs near Tahiti for which there are several surveys, it is found that for one 70% of the fish stay between the surface and 120m and for the other 55% between 120 and 200m.

Seasonal variations. Data from the skipjack fishery show seasonal variations which are identical for both FADs and general fishing. Acoustic surveys take place in one season only, corresponding to that of maximum abundance of tuna. However, for the FAD regularly surveyed, density of fish continuously decreases from level 10 in November to level 1 in March.

Daily variations. Fish densities measured at various periods of the same day indicate substantial variations. The results of a series of surveys carried out over a 24 hour cycle are shown in Fig. 6. During that particular cycle, abundance is at its maximum during the night. The average depth of aggregation is then lower and fish are closer to the FAD.

4.2.3 Remarks

The studies carried out to acquire knowledge regarding the biological processes connected with FADs are still largely insufficient. The very wide variability found in preliminary study shows that observations would have to be numerous, sustained and varied in order to obtain reliable answers to questions raised by the FAD phenomenon and consequently, to be able to use it rationally in fisheries.

5. ASSESSMENT OF SOCIO-ECONOMIC IMPACT

As the fisheries socio-economic context is not known in detail, it is not possible to assess the precise impact of introducing FADs. The increase in overall.production, if there was one, did not cause a drop in the sale price of fish (SMA, 1989). Fishing on FADs means better yield (20% on an average for skipjack fishermen). On the other hand, fuel consumption is reduced for poti-marara fishermen. FADs therefore improve fishery profits. In addition, FADs make fishing more comfortable as fish are more easily found.

From the overall economic point of view, the FAD project cannot be considered a positive contribution at this time. Production has not notably increased, therefore there is no creation of additional resources. The high cost of the project, which is entirely supported by the Government of French Polynesia Territory, increases the fishery activity costs. As a matter of fact, the project is at present serving as an indirect subsidy to the fishery sector.

6. LEGAL PROBLEMS

The FAD project has been carried out on the initiative of the Government of French Polynesia. The Government is responsible for the design, financing, implementation and supervision of the project.

7. FISHERY MANAGEMENT RELATED ASPECTS.

The introduction of FADs in French Polynesia's fisheries has not raised new problems in the management of the existing fisheries.

The main problem in the management of high sea resources of French Polynesia remains the development of their fishing. The primary issues involved are the acquisition of the needed knowledge and the formulation of exploitation projects.

REFERENCES

ANON, Etudes pour le développement de l'utilisation des Dispositifs de Concentration de Poissons en
1985 Polynésie Francaise. EVAAM-IFREMER-ORSTOM, 30p (révisé en 1989)

CAYRE, P. and J. CHABANNE, Marquages acoustiques et comportement des thons tropicaux
1986 (albacore: *Thunnus albacares* et listao: *Katsuwonus pelamis)* au voisinage d'un dispositif concentrateur de poissons. *Océanogr. trop.*, 21(2): 167–183.

CHABANNE, J. and B. UGOLINI. La pêche bonitière en Polynésie Francaise en 1983, 1984 et 1985.
1986 *ORSTOM Tahiti Notes et Doc. Océanogr.* 32: 42p.

DEPOUTOT, C., 1987. Contribution a l'étude des Dispositifs de Concentration de Poissons à partir de
1987 l'expérience polynésienne. *ORSTOM Tahiti Notes et Doc. Océanogr.*, 33: 159p.

KLEIBER, P., A.W. ARGUE and R.E. KEARNEY, 1983. Assessment of skipjack *(Katsuwonus*
1983 *pelamis)* resources in the central and western Pacific by estimating standing stock and components of population turnover from tagging data. *Tuna and Billfish Assessment Programme Technical Report.* 8: 40p.

MARCILLE, J., Nouvelles Techniques pour développer la pêche thonière a partir des Territoines
1979 Francaise du Pacifique Sud. La Peche Maritime, 1219: 590–594.

PETIT, M. AND M. KULBICKI, Radiométrie aérienne et prospection thonière dans la zone
1983 économique exclusive de Polynésie Française. *ORSTOM Tahiti, Notes et Doc. Océanogr.*, 20, 98 p.

S.M.A., Bulletin statistique du secteur de la mer – Année 1988. Ministère de la Mer, Service de la Mel
1989 et de l'Aquaculture. Polynésie Française, : 98 p.

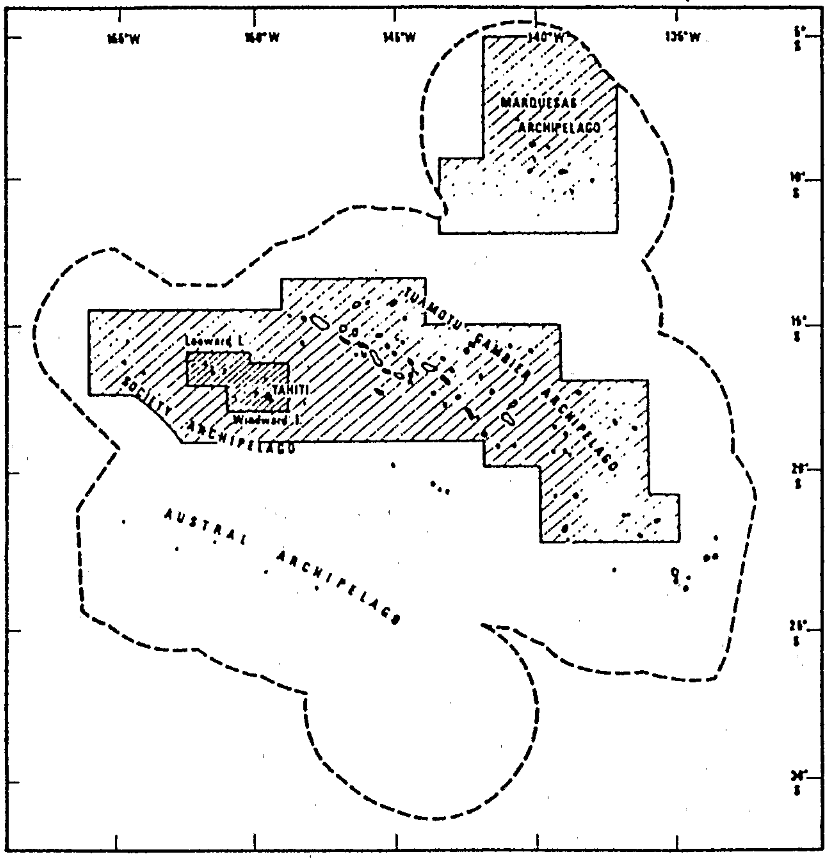
UGOLINI B. and R. ROBERT, Dispositifs de Concentration de Poissons en Polynésie Française. *La*
1982 *Péche Maritime,* 1256: 631–633.

Table 1. Tuna catches (tons) in French Polynesia (Longline=total catch (80–90% tuna).

Years	Deep Fishery Long-line	 Artisanal	Surface Fishery Skipjack Fish
1983	1662	?	1490
1984	2683	?	2345
1985	4907	?	1620
1986	4407	400	1750
1987	4434	300	1630
1988	3243	250	1340

Table 2. FADs operations in French Polynesia Total number=FADs at sea since 1981; In operation=FADs at sea in October 1989; Coast dist.=mean distance from coast in nautic miles; Depth=mean anchored depth in meters.

	Aust. Ar.	Marq. Ar.		Soc. Ar. Lw I.	Ww I.	Tuam. Ar.	French Polynesia
Total number	8	17	79	59	20	9	113
In operation	0	7	23	15	8	5	35
Coast disc.	1.7	1.6	5.8	6.6	3.6	2.6	4.6
Depth	631	619	1711	1797	1457	1228	1435
Days at sea	117	415	239	240	237	145	308



Tuna resources area.

Artisanal skipjack fishery area.

----- *E.E.Z. limit.*

Figure 1. French Polynesia EEZ, surface resources and fishery.

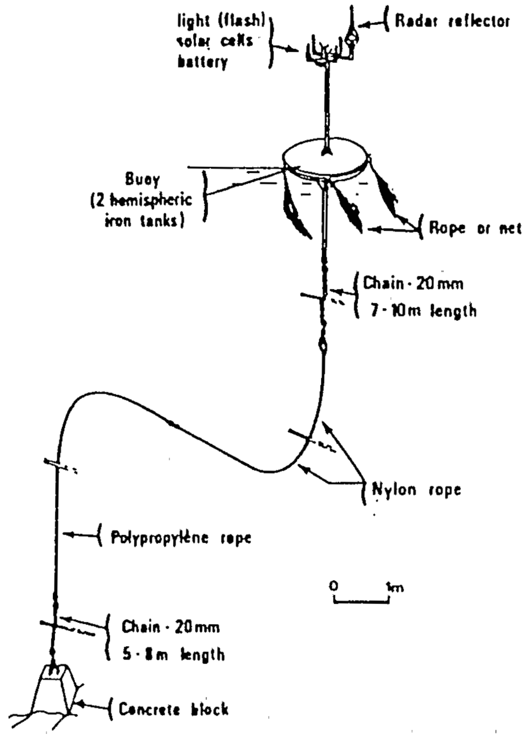


Figure 2. Fish Aggregating Device used in French Polynesia.

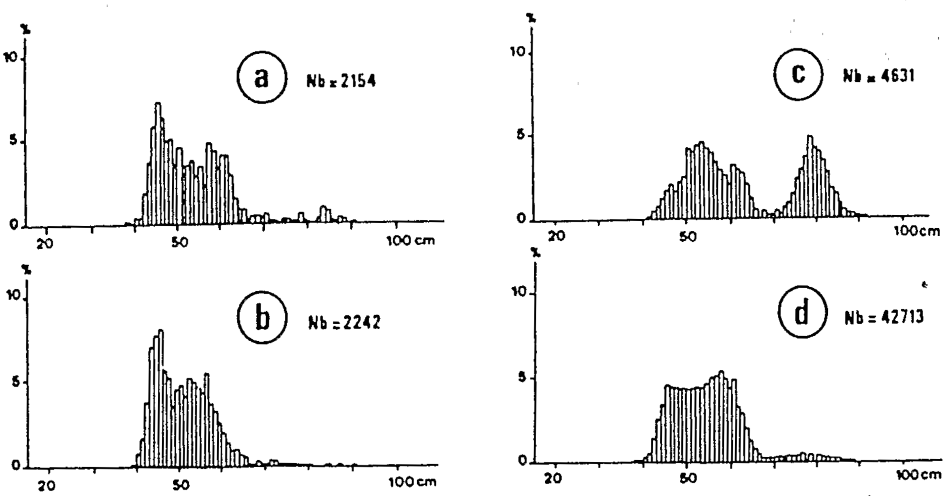


Figure 3. Skipjack length structures in skipjack fishery catch.
a=FAD b=logs c=small fishes schools d=free

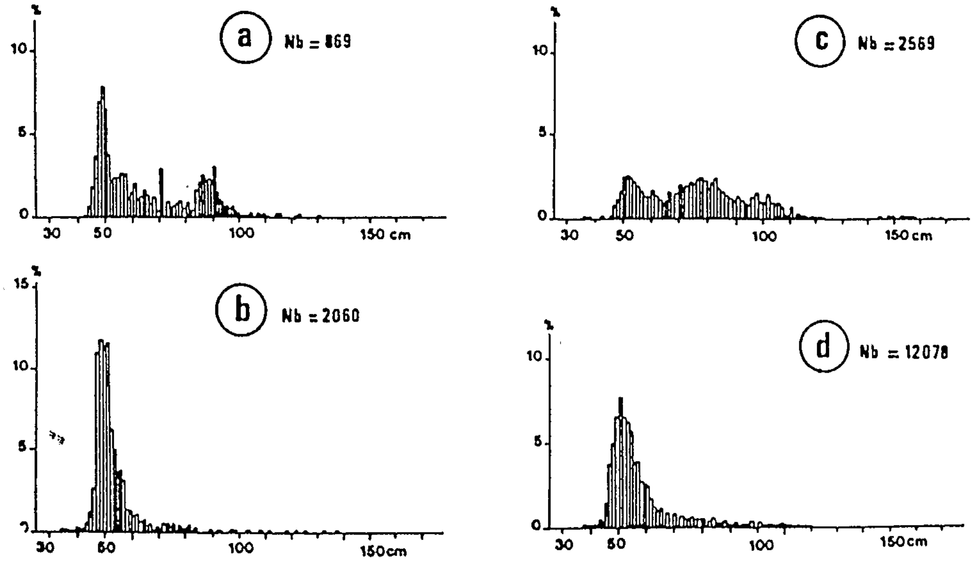


Figure 4. Yellowfin length structures in skipjack fishery catch.
a= FAD b= logs c= small fishes schools d=free

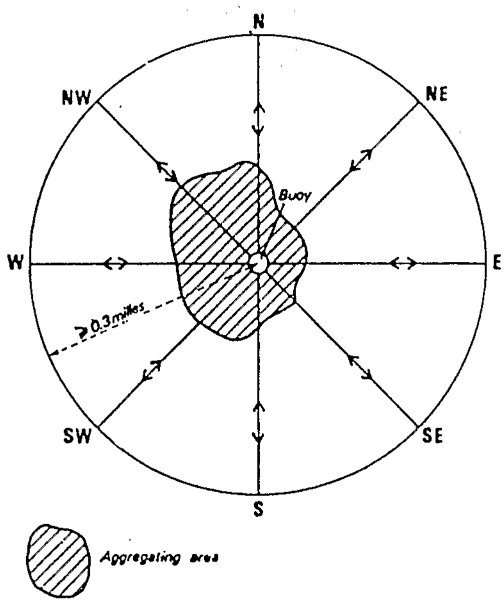


Figure 5. Echo-survey diagram around the FAD.

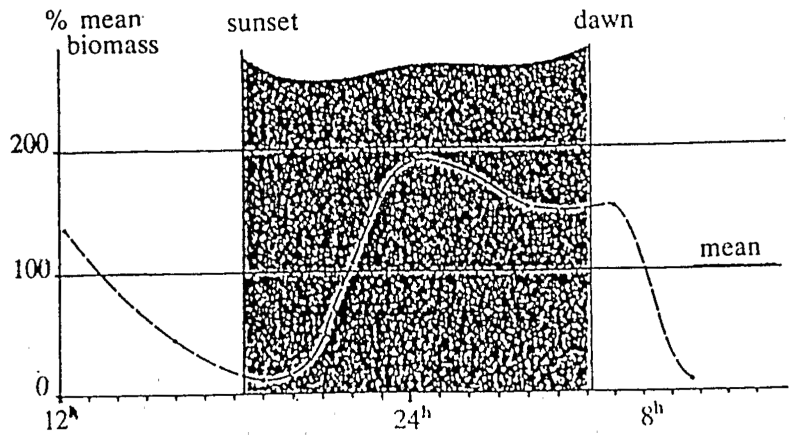


Figure 6. Daily biomass variations around a FAD measured by echo-integrator.

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