Do FADs influence the geographical distribution of dolphinfish (*Coryphaena hippurus*)?

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Abstract

For most fisheries, increasing the local production of pelagic fish is the main objective of Fish Aggregating Devices (FADs). This does not rule out the existence of a larger-scale impact, especially on the migratory behaviour of fish. The analysis of data collected during 25 experimental fishing surveys around Martinique between 1995 and 1997 has led to the hypothesis that FADs influence the migratory behaviour of young dolphinfish. Unlike recent studies of dolphinfish migration in the Caribbean, which tend to show an annual migration pattern with a seasonal passage through the French West Indies, the experimental fishing surveys done over more than a year on a monthly basis on a single cohort, show that the migratory pattern of part of the regional stock could be disrupted. This analysis has made it possible to estimate an average growth rate for this species during the first year of life.

Introduction

Given the very considerable fishing of coastal reef fish and market demand, which is not covered by local production, maintaining a fishing activity in Martinique henceforth means redeploying the fleet to the offshore pelagic species. As early as 1985, in his study of tuna resources in the Lesser Antilles, Marcille mentioned the potential for developing small-scale fisheries on tuna through the use of Fish Aggregating Devices (FADs). He recommended that research be conducted in order to better understand the distribution of the different species and to improve catching techniques.

The mechanisation of the "yoles" (small boats without decks), which began in Martinique in the middle of the 1950s, has considerably extended the range of these small fishing boats, which traditionally go out for daily fishing trips (<12 hours). Thanks to their outboard motors, it has become possible to prospect much larger areas and to go offshore to look for large pelagic fish on logs. In Martinique, this mode of fishing is called "fishing at Miquelon", probably to underline the distance from the coast. The target species of "Miquelon" fishing is dolphinfish, but wahoo (*Acanthocybium solandri*), rainbow runner (*Elagatis bipinnulata*), yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tunas are also landed regularly. "Miquelon" fishing is done seasonally from December to May. Its difficult work requires a crew with excellent stamina. Some fishermen travel almost 100 nautical miles per day at more than 20 knots on seas which are often rough, looking for logs or flocks of birds indicating schools of fish. Following the initial trials in Martinique (Sacchi & Lagin, 1985) and after several development programmes, FADs today represent an operational tool for Martinique's artisanal fishing fleet. The initial objective which led to the use of FADs was to increase the concentration of fish in order to improve the efficiency of the fishing activity. But this does not exclude the existence of an impact on a much larger scale, in particular by changing the migratory behaviour of some species. Experimental surveys on FADs in the waters around Martinique done by Ifremer between 1995 and 1997 showed a monthly increase in the size frequencies of dolphinfish catch. This increase leads us to wonder about a possible change in the migratory pattern of the species brought by the FADs. Although, the data collected during this exploratory study is inadequate to demonstrate anything about migration patterns of dolphinfish in the Caribbean region, this paper has, as its main objective, to discuss a hypothesis. Do drifting and anchored FADs influence the geographical distribution of this species, which has very strong associative behaviour?

Material and methods

The method used was based on experimental fishing surveys done monthly over the two years of the study. These surveys lasted seven days and were done using a chartered fishing boat, the *Polka*, which was fitted out and equipped for the needs of the study. The *Polka's* crew was made up of two fishermen and two biologists. Since the programme covered all the pelagic species likely to be present in the zone surveyed, various fishing techniques were used both by day and by night. The surveyed water layer went from the surface to a depth of 600 m, different variations of the drifting longline being chosen as the main gear:

- drifting horizontal surface longline (89 sets);
- drifting oblique longline (115 sets).

Apart from the different types of longline, the following fishing techniques were also used:

- trolling with artificial lure (during daytime movement of the boat);
- trolling with fresh bait (as soon as dolphinfish were visually detected);
- driftline fishing with fresh bait (when dolphinfish were aggregated around the boat).

Alongside the experimental fishing, underwater observations were carried out when weather conditions permitted either by divers or using an underwater video camera linked to the boat. The advantage of the direct observations was they were not distorted by catchability linked to the fishing gear used. They also enabled the observation of the small fauna associated with FADs. For some species, and in particular for small

dolphinfish, underwater observations made it possible to use gear whose size was suited to catching the fish on the fishing site. For each pelagic fish caught, a set of biometric and biological parameters was noted:
- exact identification of the species;
- measurements: fork length and weight;
- identification of the sex and stage of maturity (see the table).

Table - Maturity stages of the dolphinfish (*Coryphaena hippurus*).

Males	1 - Immature	Tests small, firm, colour pale flesh to pink
	2 - Maturing	Tests enlarged, colour pale pink to white, milt extruded after cutting and squeezing
	3 - Mature	Milt runs out after a little pressure on body cavity
Females	1 - Immature	Ovary long and thin, hollow tube, red to pink
	2 - Maturing	Ovary much enlarged, eggs easily visible, bright yellow to orange
	3 - Mature	Ovary distended, very large with clear eggs

All the information collected was keyed into the computer using Access for Windows. The size-weight relationship was calculate separately for males, females and the whole sample. After logarithm transformation, the difference in the slope values was examined using covariance analysis. Student's *t*-test was used to test the isometry (Massuti *et al.*, 1999). For the date-length relationship, due to the limited data (catches from experimental fishing only), the growth rate estimate was only calculated by linear regression.

Results

Dolphinfish was the predominant species, with 224 fish caught. The size-weight relationship was initially calculated by separating the females (n = 156) from the males (n = 68). Both regressions lead to positive allometry but the covariance analysis shows that the curves are not significantly different. The relationship was then calculated using all the data (fig. 1).

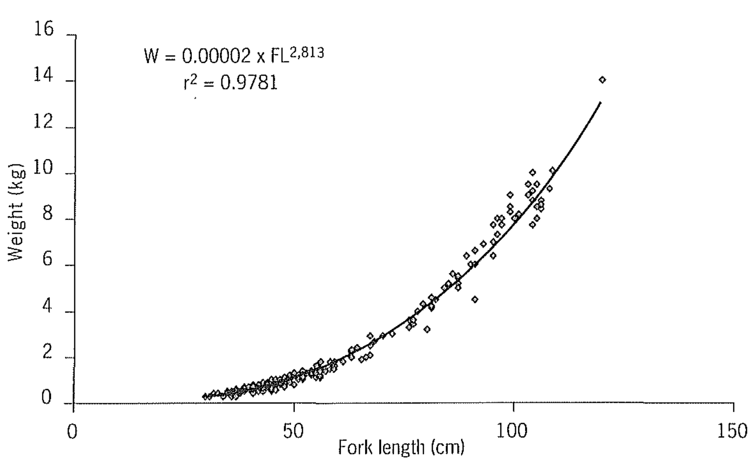
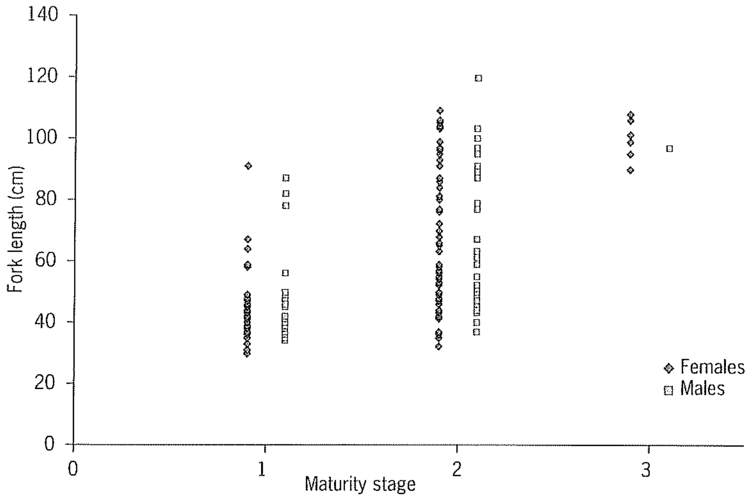


Figure 1
Size-weight relationship of dolphinfish (*Coryphaena hippurus*) established from catches made in Martinique.

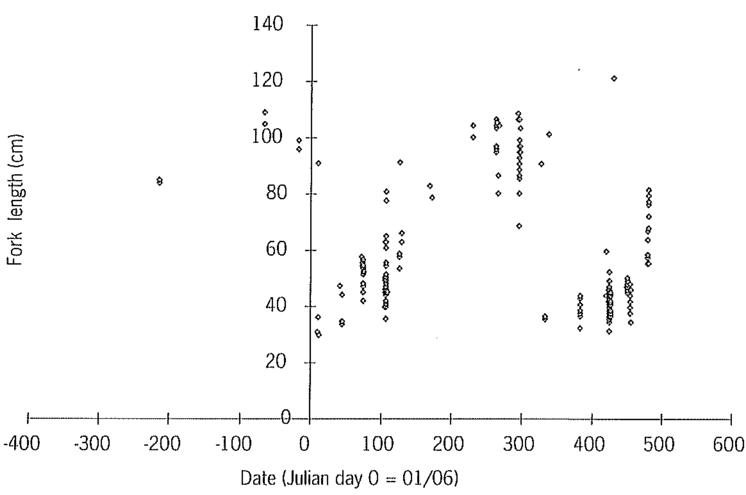
From 40 cm fork length, many males and females have gonads in the process of maturing. This observation confirms the early sexual maturity of dolphinfish (fig. 2). Some spawning females and one sperm-available male (fork length approximately 100 cm) were also found in the zone surveyed.

Figure 2
Maturity stages-length relationship of dolphinfish (*Coryphaena hippurus*) established from catches made in Martinique.



An analysis of the size of the dolphinfish related to the date of the catch shows a characteristic distribution of the data (fig. 3). This distribution leads us to formulate the hypothesis that recruitment starts in July each year. On the basis of this hypothesis, the initial data have been regrouped as follows: for each point between the lines of the equations $y1 = x/5 + 80$ and $y2 = x/5$, $x = x + 365$ (difference of one year); for each point underneath y2, $x = x + (2 * 365)$ (difference of two years). After moving the zero on the time origin to the 1st January 1996, we get a new representation of the data. The slope of the linear regression on this new basis provides an assessment of the growth rate. Between 30 and 120 cm fork length, the rate is assessed at 0.2 cm per day (fig. 4).

Figure 3
Size composition of dolphinfish catches (*Coryphaena hippurus*) related to dates of catch.



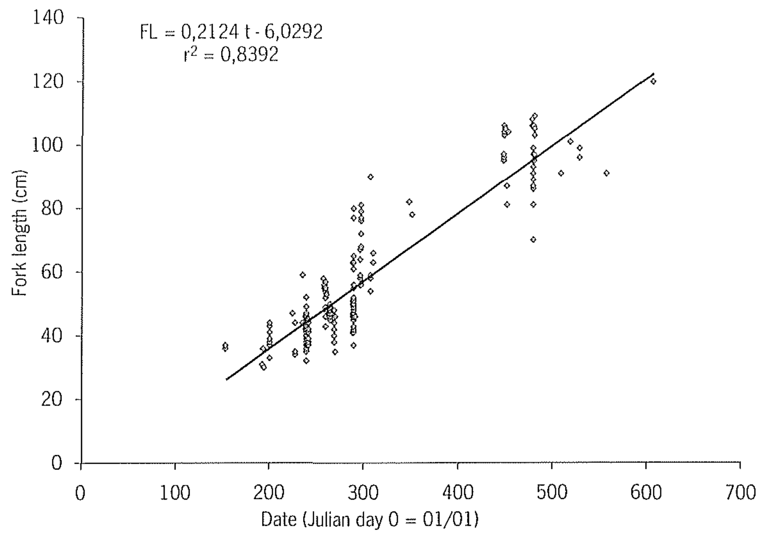


Figure 4
Evaluation of a growth rate for dolphinfish (*Coryphaena hippurus*) in Martinique.

Discussion

Regarding the weight/length relationship, covariance analysis shows that the male and female curves were not significantly different. This is probably the consequence of on-board weighing, which does not allow for precision and leads to a strong variance in weight measurements. Using different sources of data (halieutic, biological and genetic), Oxenford & Hunte (1986a) have postulated for the region (FAO zone 31) a distribution of dolphinfish in two stocks, each with its own migratory pattern: a southern stock limited to the north by the Virgin Islands and a northern stock going from Puerto Rico to North Carolina (fig. 5).

This migration hypothesis is based on an analysis of the monthly catches surveyed in the different fisheries in the region. We can also see that the monthly distribution of size frequencies of dolphinfish in Barbados, presented by the same authors (Oxenford & Hunte, 1983), shows, as in Martinique, a steady growth in the size of the fish. Only a sedentary behaviour pattern can explain such an observation over several consecutive months. The authors assimilate this modal progression to the growth of individuals. They deduce a daily growth rate of 0.153 cm, calculated on a standard length of fish of about 60 to 120 centimetres. The same phenomenon of monitoring a cohort is presented for Saint Lucia (Murray, 1985). The author used the Cassie method (1954) to calculate the different growth rates. This gave an average rate of 0.178 cm per day. These rates are fairly close to those obtained in Martinique on dolphinfish between 30 et 120 cm at the fork (0.2 cm/day) and those obtained by Beardsley (1967) (0.199 cm/day) for the first year of life of dolphinfish in Florida. Much higher growth rates have been obtained in fish-farming: 0.59 cm/day (Hassler & Hogarth, 1977) and 0.96 cm/day

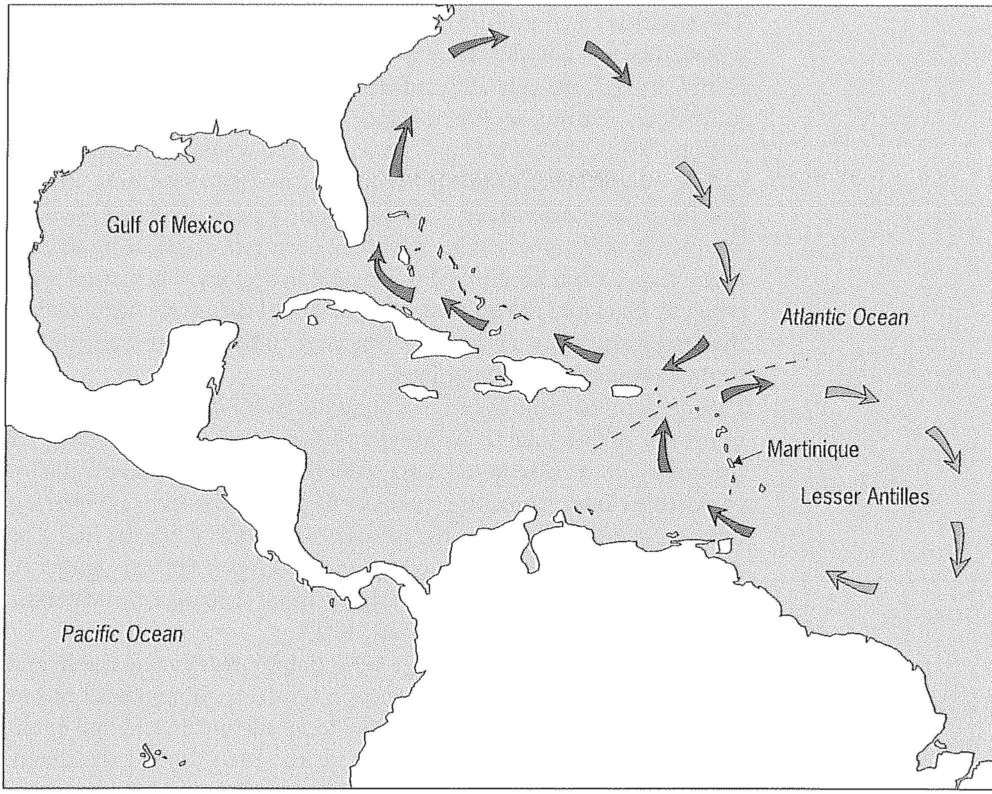


Figure 5
Migration pattern of the two dolphinfish stocks proposed by Oxenford & Hunte (1986). The dark arrows show the part of the migration circuit where catch data are available, the light arrows, where catch data are not available.

(Schekter, 1982). They tend to show that the availability of food can lead to very considerable differences in growth in the natural environment. The monthly size distribution observed in Martinique, Saint Lucia and Barbados stems from the spread of the spawning season, which is well-known for this species (Beardsley, 1967; Palko *et al.*, 1982; Oxenford & Hunte, 1986b; Oxenford, 1999).

The hypothesis of the migration of the southern stock, deduced from the difference in the production peaks in the various Caribbean islands, would seem to be incompatible with the possibility of observing the increase in a cohort over a long period. Consequently, we formulate the hypothesis of a specific behaviour pattern of dolphinfish according to the age of the individuals. The range of mobility of dolphinfish would seem to increase with age. Young individuals seem to stay in their recruitment zone as long as they find the necessary prey. With age, their trophic needs increase rapidly to satisfy energy requirements linked to reproduction. The mobility of the fish seems to increase in order to optimize the possibilities of meeting logs (prospecting behaviour). The largest dolphinfish would look for logs with a lot of prey far offshore. As Palko *et al.* (1982) suggest, their migration would be strongly influenced by the distribution and the drift of floating objects.

The monthly catch profiles of the different islands during the fishing season, used as a basis for the proposal regarding the regional migration of two stocks, are probably influenced by the weight of the large individuals. Fishing on floating logs makes the largest fish very vulnerable. When the log is found, practically the whole associated school will be caught, whereas this is not the case for free-swimming schools and for young individuals. The production peak observed for each island may correspond to the maximum occurrence of floating objects in the respective zones, linked to regional hydrology. The pattern proposed by Oxenford & Hunte (1986a, b) would therefore correspond to the migration of part of the stock (the large individuals) closely linked to the movement of drifting logs.

During the first months of life, young dolphinfish could therefore be much less mobile than is habitually shown in migration patterns for the species. In which case, the FAD network anchored around the islands could contribute to making part of the stock sedentary by offering hunting grounds suited to the feeding behaviour of the species. The ability of certain pelagic fish to navigate from one FAD to another in the same island network has been shown more than once by ultrasonic tagging (Cayré, 1991; Marsac *et al.*, 1995).

The arrival in Martinique of large adult dolphinfish during the second part of the "Miquelon" fishing season (April to June) could favour reproduction in these waters. The new "local" recruits would find favourable feeding and growth conditions on the FADs around the island. The stomach contents studied by Oxenford & Hunte (1999), made up largely of fish known to be associated with drifting floating objects, show that the search for prey constitutes an important factor in determining the aggregation of dolphinfish.

Conclusion and prospects

The simultaneous monitoring of tagged dolphinfish and drifting logs would make it possible to understand the aggregating behaviour of the species better. At the same time, such operations would improve our knowledge of the growth of this species in the wild. If, through tagging operations, it is proved that the migration of dolphinfish is really conditioned by floating objects, the area of distribution of the stocks would depend on the movement of the logs on the oceans and would therefore be closely linked to regional hydrology. In the past, tree trunks were probably the most frequent type of floating object on the three oceans. With the development of maritime shipping in the middle of the nineteenth century, cargo stowed on the deck and lost during storms provided other types of objects, not always natural, whose presence at sea was accidental. Fluctuations in the availability of floating objects may have repercussions on the size of dolphinfish stocks. The considerable development of anchored FAD networks in certain regions may also change the migratory behaviour of dolphinfish. This underlines the need to monitor catches and to regulate access to these devices. Although no sign of stock depletion has been shown, hypotheses on the structure of regional stocks have led certain countries in the Western Central Atlantic region to draw up recommendations on fishing dolphinfish. It would seem henceforth to be essential to continue research in order to define better the fishing limits which would make it possible to manage and protect a shared regional resource better.

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