Wahoo Landings in the Lesser Antilles: Biased Samples Cause Problems for Stock Assessment

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ABSTRACT

Length-based approaches for stock assessment, a well-known and important class of techniques for tropical fisheries in particular, require reliable detection of modes in length-frequency distributions that correspond to year-classes. They also are based on the premise that it is possible to adequately represent the size structure of the population by sampling the commercial fishery. This paper documents how even when these assumptions are not well met, examination of length frequency samples from the fishery may still allow the development of testable hypotheses concerning stock movements and life history. The example described is the regionally important wahoo (*Acanthocybium solandri*) fishery of the Lesser Antilles, and includes eleven years of length-frequency sampling from St. Lucia, W.I.

KEYWORDS: stock assessment, size structure, population parameters, growth, mortality, wahoo, stock movements.

INTRODUCTION

The use of length-frequency distributions to study processes of fish population dynamics is now considered a well-accepted tool (Gulland and Rosenberg 1992), particularly in tropical fisheries. There are, however, fundamental assumptions regarding the use of such approaches which must be satisfied before length-based examination of the dynamics of fish populations can be successfully undertaken. Shepherd *et al.* (1987) have categorized length-frequency data from different types of fisheries, highlighting some situations where length-based approaches to stock assessment were inappropriate. One such example include the so-called Type A length-frequency data, where there is only one observable mode in the data and the mode does not progress with time. In contrast, Type B length-frequency data include only a single mode, and the mode shifts in time as the cohort increases in average size.

The latter type of length-frequency data is well-suited for length-based stock assessment, whereas the former type (A) is not.

In this paper, we use data from a fishery for the tropical scombrid known as wahoo (*Acanthocybium solandri*) to illustrate an example of a Type A fishery in the Lesser Antilles. In these islands, the fishing season for pelagic fish species is considered to extend from September to the following August, with the peak season from January to June (Figure 1; Mahon *et al.*, 1990). The landings and catch per unit effort (CPUE) of these species are highly variable from one season to another. The wahoo, *Acanthocybium solandri* Cuvier, is one of the two most important species in trolling fisheries for large pelagics in this region, the other being the dolphinfish, *Coryphaena hippurus* (Mahon *et al.*, 1990).

In St. Lucia, the major fishing areas for these species are on the east and southeast coasts (Murray *et al.*, 1988); landings of the wahoo represented on the order of 14% of total estimated landings in 1988 (Murray and Nichols, 1990), 5% in 1989 and 10% in 1990 (unpublished data, Government Statistical Department, 1992). The sharply peaked fishing season does not appear to vary much in timing from season to season (Mahon *et al.*, 1990). In general, for the southern Windward Islands and Barbados, the pelagic fishing season can be considered to extend from September to the following August (*ibid.*), but in St. Lucia most wahoo are landed between mid-November and the end of the following July (Murray, 1989; Murray and St. Marthe, 1991). Fishing effort is thought to vary seasonally in phase with these landings (Murray, 1989).

In Grenada, the fishing season for wahoo appears to be similar to that of St. Lucia (Mahon *et al.*, 1990) while in Barbados the group "kingfish", which is mainly wahoo, shows a more even mean annual pattern (*ibid.*).

Using data from the St. Lucia wahoo fishery, we discuss the implications of attempting to derive population parameters from length samples of a Type A fishery. Finally, we show how even when length-frequency samples from the fishery are found to be of little use for stock assessment purposes, they may at least allow inferences or the development of testable hypotheses concerning stock movements and life history. Such insights are particularly important, as there is comparatively little published information available on this circumtropical species, which forms the basis of significant commercial and recreational fisheries throughout the world (Collette and Nauen 1983).

METHODS

In St. Lucia, with the exception of March to May 1987 and January to April, 1988, the fork length measurements of wahoo were taken daily by the on-site fisheries data collector at Dennery to the north east of the island where, in 1992, some 36 fishing boats operated out of, and landed most of their catch (Dept. of Fisheries, unpubl. data). For March to May 1987 and January to April 1988, fish

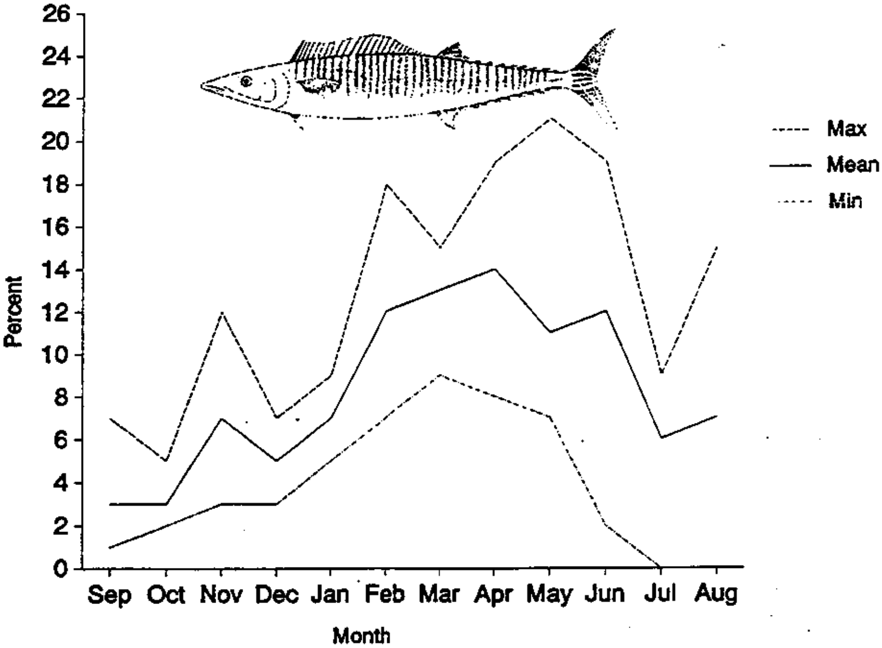

Figure 1. Seasonality of wahoo catch/trip at Dennery, St. Lucia, 1984 -1989 (after Mahon *et al.*, 1990). Inset: *Acanthocybium solandri.*

were measured at the St. Lucia Fish Marketing Corporation Ltd. (SLFMC) in Castries (Murray, 1989).

Length measurements of wahoo collected in St. Lucia from 1982 to 1992, were aggregated into 5-cm class intervals (see Table 1), without differentiation between the sexes. Length samples were aggregated to reflect the pelagic fishing season in the region, rather than the calendar year. Such an aggregation should have allowed us to better follow the growth of a given cohort, both within and between pelagic fishing seasons.

We had intended to obtain estimates of total mortality coefficient, Z, from the time series of seasonal length frequency distributions. Such estimates of Z would then be compared to determine any trends in mortality over the eleven year period in the wahoo fishery of St. Lucia. Length distributions of wahoo landed in Grenville, Grenada (Finlay and Rennie, 1988), were to be treated similarly, although considerably less data were available. It was also intended that we would be able to arrive at estimates of maximum sustainable yield per recruit, consistent with the approach summarised in Figure 2.

Table 1. Length frequency distributions of wahoo, *Acanthocybium solandri*, aggregated over the pelagic fishing season.
St. Lucia, W.I.

	Season										
Mid-Length	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
32.5	2	2	0	4	0	0	0	0	0	0	0
37.5	5	3	0	0	0	0	0	0	0	0	6
42.5	10	9	0	6	9	0	0	0	3	0	0
47.5	19	27	0	31	7	2	0	0	1	0	1
52.5	33	34	0	20	3	4	1	1	1	1	4
57.5	18	15	4	32	17	1	1	0	3	1	0
62.5	56	42	14	69	20	31	1	8	12	1	5
67.5	21	21	2	46	36	14	14	18	26	14	6
72.5	57	49	11	87	24	17	6	8	6	6	4
77.5	70	1139	117	108	32	42	39	27	28	39	16
82.5	244	584	102	122	7	22	21	12	8	21	6
87.5	237	61	4	709	46	125	8	73	24	8	19
92.5	580	529	15	102	15	313	28	165	57	28	66
97.5	66	81	10	337	30	125	77	50	113	77	47
102.5	31	112	9	115	4	66	30	28	48	30	41
107.5	76	128	18	173	16	41	20	18	28	20	20
112.5	44	26	11	143	4	41	32	19	8	32	19
117.5	19	18	5	106	4	37	10	4	4	10	9
122.5	54	51	15	83	1	24	5	43	0	5	5
127.5	9	4	1	25	3	3	10	6	0	10	2
132.5	14	0	0	24	0	4	12	5	11	12	0
137.5	8	7	0	17	0	3	2	1	0	2	0
142.5	8	0	1	7	0	1	0	0	0	0	0
147.5	1	1	0	18	1	0	0	0	0	0	0
152.5	2	3	1	8	0	0	0	0	0	0	0
157.5	0	0	0	2	0	0	0	1	0	0	0
162.5	0	0	0	0	0	0	0	0	0	0	0
167.5	0	0	0	2	0	0	0	0	0	0	1
172.5	0	0	0	2	0	0	0	0	0	0	0
177.5	0	0	0	4	0	0	0	0	0	0	0
182.5	0	0	0	1	0	0	0	0	0	0	0
187.5	0	0	0	0	0	0	0	0	0	0	0
192.5	0	0	0	2	0	0	0	0	0	0	0
197.5	0	0	0	37	0	0	0	0	0	0	0
202.5	0	0	0	1	0	0	0	0	0	0	0
207.5	0	0	0	4	0	0	0	0	0	0	0
212.5	0	0	0	3	0	0	0	0	0	0	0
SUM	1784	2946	340	2450	279	1652	916	487	381	317	277

RESULTS

The data available from the St. Lucia fishery are summarized in Table 1. Examination of annual length-frequency distributions indicated that the modes apparent in the fishery samples from St. Lucia (generally one or two) were not progressing over time as would be expected (Figure 3). Even when data from a certain pelagic season were disaggregated into months (Figure 4), the same pattern emerged. In general, one or more often two modes were apparent, and again, these modes did not progress over time. Further indication of the lack of modal progression is provided in Figure 5, which shows the average monthly fork length for the pelagic season spanning 1982/83. While the average length increases until November, there is no trend thereafter. The lack of trend in average size is typical of other years as well.

DISCUSSION

Given the evidence presented in Figures 3-5, it was apparent that the St. Lucia wahoo fishery is an example of a Type A fishery as described by Shepherd *et al.* (1987). We had reached the decision point indicated on the flow diagram on Figure 2, and determined that the modes of the length-frequency distribution were not progressing over time in a manner consistent with the growth of a cohort. Thus, we concluded that further analysis using length-based approaches was not warranted.

Previous estimates of total mortality for wahoo off St. Lucia were obtained by Murray and Sarvay (1987), and Murray and Joseph (in press), but were predicated on estimates of growth parameters derived by use of a software tool known as ELEFAN I (Brey and Pauly, 1986; Gayanilo *et al.*, 1989). ELEFAN I provides reliable estimates of growth parameters when the modes of length frequency distributions are clearly defined and progress over time. However, in the case of the St. Lucia wahoo fishery, the observation that the major modes of the length-frequency distribution are essentially stationary probably indicates that earlier estimates of Z were biased.

While it was not possible to use the data presented here for stock assessment purposes as originally intended, examination of the length-frequency distributions still provide important insights into the life history and movements of wahoo. As noted by Shepherd *et al.* 1987, Type A fisheries are indicative of stocks which are either highly migratory, or the fishery itself is extremely size-selective. Of the two hypotheses, we favour the former for wahoo off St. Lucia. The other trolling fishery of consequence to St. Lucia is for dolphinfish, and a wide range of lengths of fish are landed even though the same hook size is employed (Figure 6). Also, in the fishing season 1984/85, there were some large (about 200 cm, Figure 3) wahoo landed, indicating that the hooks being used are capable of capturing fish larger than the usual 80-100 cm range, if such fish are present in the population.

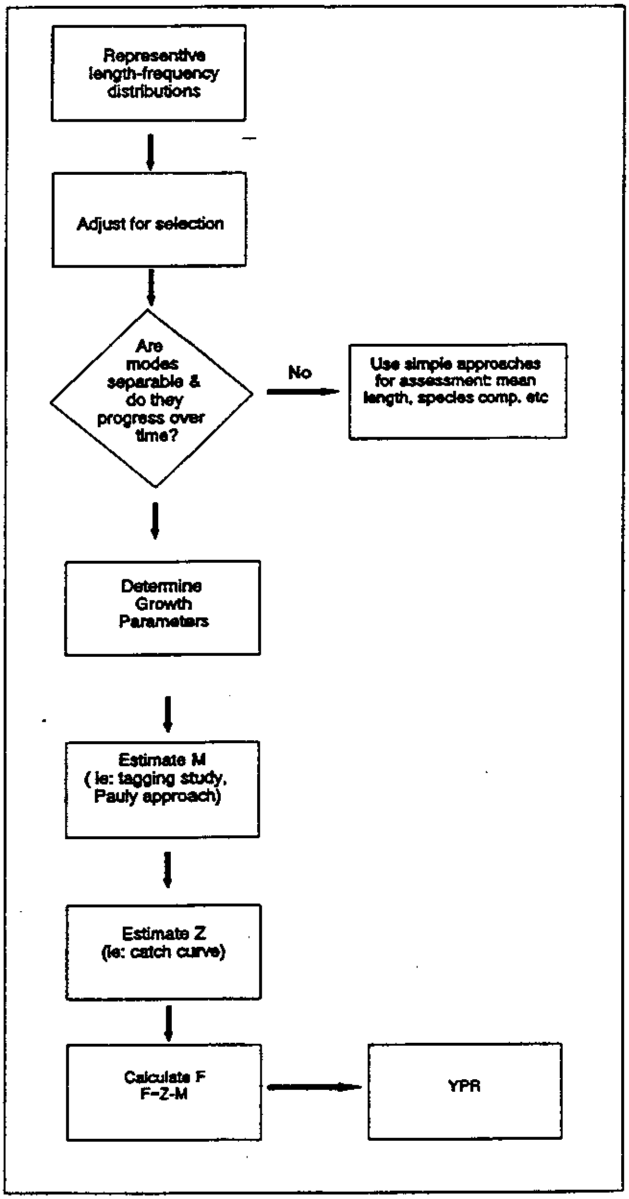

Figure 2. Flow diagram showing the planned approach for the analysis of length-frequency data from commercial landings.

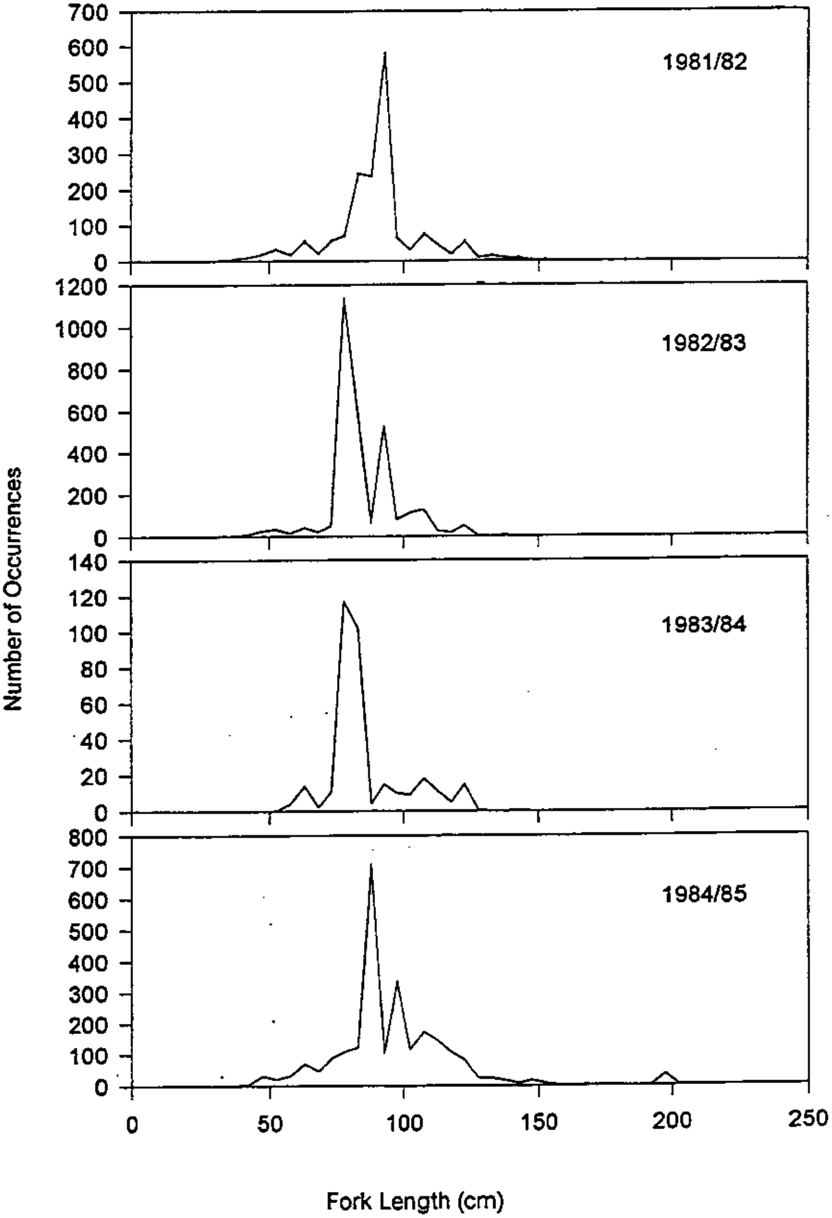

Figure 3. Length-frequency distributions of wahoo for the fishing seasons 1981/1982 to 1984/85 aggregated over the fishing season (September to August), St. Lucia.

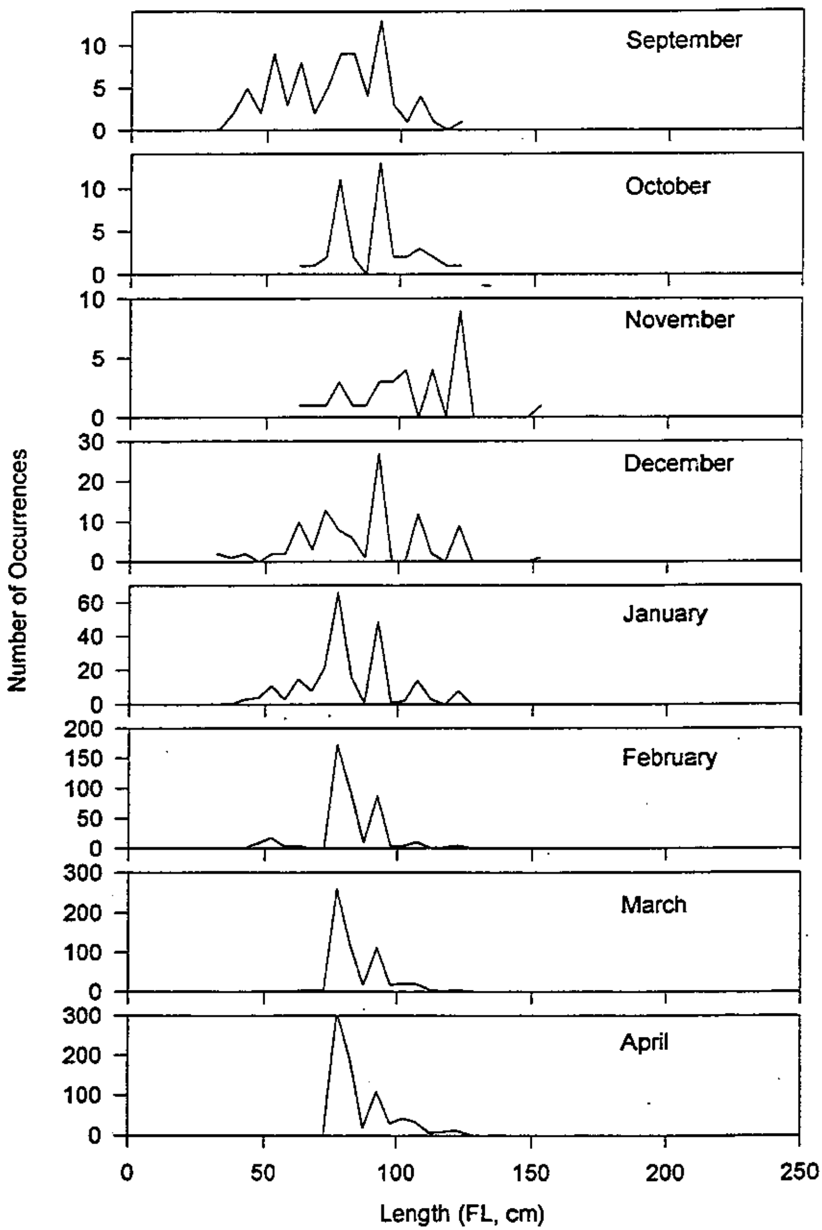

Figure 4. Length-frequency distributions of wahoo for the fishing season 1981/82 aggregated by month, St. Lucia.

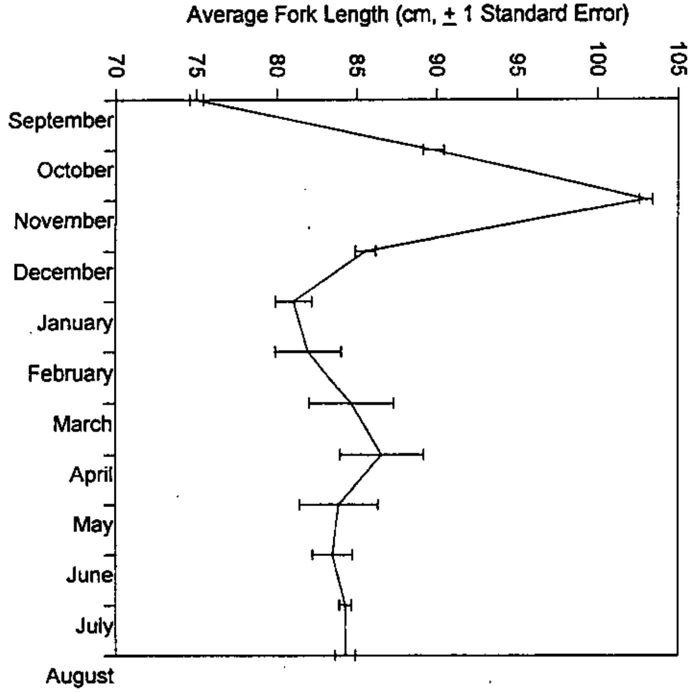

Figure 5. Variation in mean monthly length of wahoo for the fishing season 1982-83, St. Lucia.

A further intriguing aspect of the length-frequency distributions is the two closely-spaced modes, particularly evident in Figure 5. It is possible that the two modes represent males and females of a single year class. Many species of scombrids are known to display sexually dimorphic growth rates, with females attaining larger sizes than males (Collette and Nauen 1983). An alternative explanation might be that the two modes reflect the selectivity of two different hook sizes being used in the fishery. However, H.D. Walters (Chief Fisheries Officer, Dept. of Fisheries, St. Lucia, pers. comm., 1993) has indicated that essentially one hook size is used throughout St. Lucia for this fishery. The fishermen who land their catch in Grenville, Grenada, also use essentially only one hook size. A final possible explanation is provided by Mahon *et al.* (1990), who noted that often in the Eastern Caribbean the species group referred to as "kingfish" includes both the wahoo and the king mackerel, *Scomberomorus cavalla*. This could also possibly lead to two modes in a "mixed species" sample. However, for the data collected in this study, the species identification problem was well-known and data collectors were trained to distinguish wahoo and king mackerel.

On the basis of this study and other available information, it is now possible to summarize existing knowledge of wahoo life history as follows:

1. Wahoo appear to be available to the fishery in all months of the year.

2. The fish do not appear to increase in average size throughout the year.

3. Typically, two closely-spaced modes appear in the annual length-frequency distributions. Those modes could represent either year classes or sexes if growth rate is sexually dimorphic, as is the case in either scombrids.

4. The modes in the length-frequency distribution do not progress from month to month.

5. The lack of modal progression appears to be indicative of a highly migratory stock, since the alternative hypothesis, that of a highly-selective fishery, does not appear supported by the available data.

6. The exploited population appears to consist of only one or two year-classes (with the possible exception of the 1984/85 fishing season).

It is possible to construct a model of wahoo life history consistent with the above observations. We suggest that recruitment of wahoo to the fishing grounds occurs throughout the year (Figure 1). This inference is consistent with a protracted period of spawning, as suggested by Collette and Nauen (1983). Since the average size of fish in the exploited population does not increase over the fishing season (Figure 5), individual fish do not stay long on the fishing grounds, at least off St. Lucia. We therefore predict that tagging studies would show relatively few recaptures close to the point of release. We also predict that because of the apparent brevity of residence on the fishing grounds, the seasonality and size composition of landings from waters of adjacent countries will differ only slightly. At present, data from other countries within the region which could be compared with the St. Lucia length frequency distributions are few. It was possible, however, to compare the length frequency distribution for Grenada, March, 1985, with data obtained during the corresponding period in St. Lucia (Figure 7). Given the number of fish measured in Grenada at that time (N= 73) the comparison is not definitive, but the results seem to support our prediction that the size compositions should differ only slightly. Through a more comprehensive program of tagging and data collection due to commence in 1994 (Anon. 1994), it should be possible to test these predictions in the near future.

Oxenford and Hunte (1986) proposed a model for the life history and migration for dolphinfish. In their model, which suggests that two stocks occur in the western central Atlantic region, the southern stock moves sequentially north through the waters of the Lesser Antilles countries. A return migration south is hypothesised via the waters further to the east. Consistent with the results for wahoo presented here, the frequency distributions for dolphinfish shown in Figure 6 show no modal progression, probably due to the highly

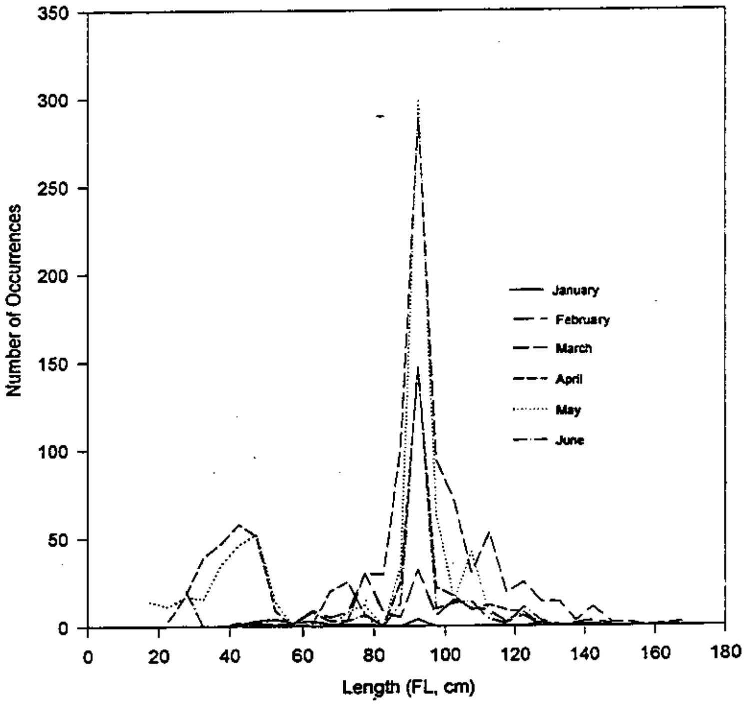

Figure 6. Monthly length frequency distribution of dolphinfish in St. Lucia for 1982 (after Murray, 1985).

migratory nature of that stock. It may be that the life history and migration model for dolphinfish also applies to wahoo.

Many Eastern Caribbean countries have identified pelagic fisheries as having the most scope for development (Anon. 1992). The suggestion that wahoo is probably a shared stock has profound implications for its future management, as expansion of fishing effort by one country may likely impact its neighbours' opportunities for similar expansion.

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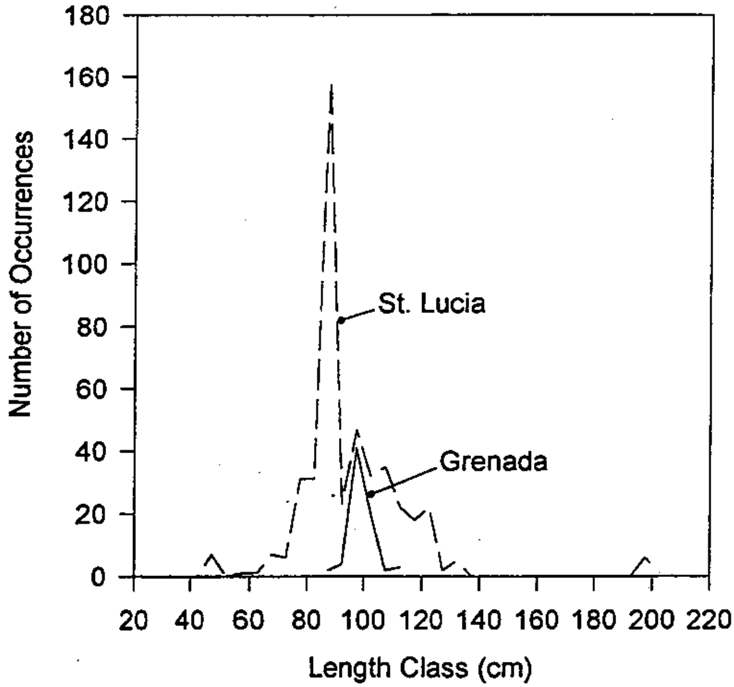

Figure 7. Comparison of length-frequency distributions of wahoo obtained in March, 1985 in St. Lucia and Grenada.

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