BIOLOGY OF SKIPJACK IN NEW ZEALAND WATERS 1973-76

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Length-frequency Distributions

Data on the 1973-74 and 1974-75 seasons were collected from catches taken by the purse seiner Paramount in the Bay of Plenty in January to March 1974 (15 catches sampled, 678 fish measured) and January to February 1975 (19 catches sampled, 1020 fish measured).

The 1975-76 season started in November 1975 off Reef Point. The area off the north-east coast of the North Island between North Cape and Cape Runaway was fished from December 1975 until the beginning of March 1976. A random sample of at least 100 fish was measured at sea from each catch by each of the three large Californian purse seiners operating at the time (137 catches sampled, 23 249 fish measured). Catches made in January and February 1976 in the Bay of Plenty by the two small New Zealand purse seiners were sampled ashore (893 fish measured). The lengths measured were fork lengths, rounded to the nearest whole centimetre. [Details of the areas fished and of the vessels fishing are given on page ?? of G. Habib's paper.]

During the 1975-76 season the Californian vessels usually worked close together. The length-frequency distributions of their catches were similar and except for a gradual shift in modal lengths there were no great changes in length composition from January to March 1976. All the length measurements taken on these vessels could therefore be grouped by intervals of about 2 weeks to provide a full record of the length composition of the catches throughout the season (Fig. 1). No fish were measured in November 1975 off Reef Point, but measurements of trolled fish indicated that the schools consisted mostly of fish 50 to 60 cm in length, with a modal length of 55 to 56 cm. The catches in December 1975 off the north-east coast were

dominated by fish of 50 to 60 cm with a modal length of 56 to 58 cm (Fig. 2, group D). This mode disappeared almost completely from the catches in the following months, and from January onwards the main mode occurred consistently at 44 to 47 cm (Fig. 2, group A). Analysis of the length-frequency distributions by means of probability paper (Cassie 1950) confirmed the existence of minor modes at 37 to 41 cm (Fig. 2, group B, January to March) and at 35 to 36 cm (Fig. 2, group C, March only).

Modes A and B shifted during the season to higher values; both modal lengths were 3.5 cm greater in early March than the corresponding lengths at the beginning of January. This increase in modal lengths over 2 months probably reflects growth of the fish and corresponds to an increase in body weight of 400 to 500 g.

A variety of growth curves of skipjack in the eastern Pacific Ocean and off Japan can be found in the literature (summarised by Joseph and Calkins 1969). The slope of the band covering these published curves indicates that fish at lengths between 30 and 60 cm grow 1.5 to 2.0 cm per month (Fig. 3). This growth rate is similar to the 3.5 cm in 2 months recorded during the present study. From these values it follows that the fish in modal groups B and C were, respectively, 3 and 6 months younger, and those in modal group D were 6 months older, than the fish in modal group A. The modal length of the fish in January to February 1975 (Fig. 2, group E, and Fig. 4) lies roughly half way between modes D and A observed in 1976. These data lead to the conclusion that the modal groups of skipjack found off the north-east coast of New Zealand differ in age by 3, or multiples of 3, months. Thus the skipjack schools found off the north-east coast of New Zealand during a single fishing season consist of fish belonging to several distinct cohorts. (A cohort is defined here as all the fish spawned at or near a particular time and moving through the fishery as a distinct group.) The data from the

three seasons indicate that as a rule one cohort dominates strongly in the catches of large purse seiners during most of the season.

There is no information on the growth pattern of the fish before their arrival off the New Zealand coast so their age is unknown. From the published skipjack growth curves it appears that the possible age range of the skipjack in the fishery is between 1 year for the smallest fish (group C) and 2.5 years for the largest fish (group D, see Fig.3). Within this age range, if growth takes place throughout the year at the rate of 1.75 cm per month which was measured in January to March 1976, the annual growth rate is 21 cm.

It follows from a comparison of the length-frequency distributions of the three consecutive seasons that few, if any, fish of cohorts that contribute large proportions to the catches during a given season occur in the catches of previous and following seasons. For example, the modal length of the cohort that appeared as group D in February 1976 would have been about 35 cm in February 1975, and the length-frequency distribution for that month shows very few fish of such a size. As another example, the cohort that dominated the catches in January to February 1975 would have had a modal length of about 70 cm in the same months of 1976, and fish of this size were not caught in the 1975-1976 season (Figs. 1 and 4).

In 1975-76 modal groups B and D were important components of the catches by the New Zealand vessels (Fig.5). Thus the modal groups that formed minor peaks in the length-frequency distributions of the catches by the large foreign vessels were much more obvious in the catches by the smaller New Zealand vessels. The reason for this difference between the catches by the two types of boats could be that the smaller fish form

smaller schools than the dominant modal groups. The New Zealand boats fished much smaller schools than the foreign boats and were perhaps selectively fishing small fish.

Some fishing took place off the Taranaki coast near the end of the season. The length-frequency distribution recorded there was entirely different from that found earlier off the north-east coast (Fig. 1). The first of the two modes off Taranaki did not fit in with any of the modes observed earlier in the season. The origin and age structure of the fish off the west coast of the North Island may be different from those of the fish found off the north-east coast.

The New Zealand skipjack catches are similar in length range to the catches in the Japanese fishery, which also show a single major mode between 40 and 50 cm (Kawasaki in Waldron 1963). Off Hawaii the catches show several main modes, one between 40 and 50 cm and others at larger sizes (Brock 1954). In the eastern Pacific the main modes occur generally at lengths greater than 50 cm (Waldron 1963). In the Bismarck Sea in 1972 skipjack were mostly between 50 and 60 cm long (Lewis, Smith, and Kearney 1974). Thus the length composition of the New Zealand skipjack occurs at the lower end of the size range found in other skipjack fisheries in and around the Pacific Ocean. It can therefore be concluded that the skipjack in the New Zealand fishery are young recruits which belong to cohorts that have not been subject to fishing elsewhere in their geographic range.

Length-Weight Relationship

Total body weights including the stomach contents (to the nearest 25 g) and fork lengths (to the nearest millimetre) were measured for

2 skipjack samples of 50 fish each, collected from purse seine catches in the Bay of Plenty on 6 March and 8 March 1976. In one sample the stomachs were empty in all but one fish. In the other sample the stomachs contained only small amounts of food; the contents of the fullest stomach amounted to only 2% of the total body weight. Thus the inclusion of the stomach contents had little effect on the overall body weight.

A linear regression equation was fitted by the least squares method to the logarithms of weight (dependent variable) and length of each fish sampled.

The equation took the form:

$$\log_e W = -11.99 + 3.19 \log_e L$$

where W = total body weight (g) and
L = fork length (mm).

This curve fitted the data well and was similar to the curve derived by Chatwin (1959) for skipjack in the eastern Pacific Ocean (Fig.6).

The weights predicted for given lengths by the equation are listed in Table 1. In combination with the length-frequency distributions this table shows that the approximate modal weights of skipjack during the 1975-76 season were: 1520 g and 3500 to 3900 g in December, 1530 g in January, and the main mode shifted to 2030 g in March.

Gonad Condition

The gonads of the fish in the two samples discussed in the previous section were examined and weighed. At body lengths between 35 and 44 cm the gonads were thread-like and weighed

mostly less than 1 g. At body lengths between 44 and 54 cm the gonads were thread- or ribbon-shaped and weighed up to 12.8 g. The sexes could not be distinguished macroscopically. The gonad weights of these larger fish formed 2 groups: a cluster of 40 points below 2 g, and a more diffuse group of 37 points centred around 5 g (Fig.7). Among the fish of 44 to 54 cm fork length those with gonads of less than 2 g in weight may be males and those with heavier gonads females. This possibility remains to be investigated histologically. The small size of the gonads and the lack of sexual difference at the macroscopic level indicate that the fish were "immature" according to the definition given by Marr (1948).

Food and Feeding

Stomach contents were investigated in the two samples. From these samples and from occasional observations throughout the season it was obvious that the euphausiid Nyctiphanes australis was the main food item taken by the skipjack schools that were fished by the purse seiners. In fact no other food was found in any of the stomachs examined. Roberts (1972) found a similar situation in skipjack caught by trolling off the northeast coast of New Zealand in November 1971, though fish made up a small proportion of the stomach contents. York (1969), however, found that off the east coast of the North Island fish (chiefly Engraulis australis) were dominant in the diet of skipjack caught by trolling and gill netting in 1969 and 1966. Both regional and behavioural factors could account for these differences in diet.

Skipjack may form large schools when they feed on Nyctiphanes and so this food item would be dominant in stomachs of fish caught by purse seine. The fact that skipjack can be caught by trolling indicates that they will take food other than Nyctiphanes when it is available.

Figure Captions

Fig. 1. Length-frequency distributions of skipjack tuna in catches made by three Californian purse seiners off New Zealand, December 1975 to March 1976.

Fig. 2. Length ranges and modal lengths A-D (indicated by X) of skipjack tuna in purse seine catches off New Zealand, 1975-1976.

Fig. 3. Modal lengths A-D of skipjack tuna in purse seine catches off New Zealand, 1975-76, superimposed on the band covering growth curves of skipjack tuna off Japan and in the eastern Pacific Ocean listed by Joseph and Calkins (1969).

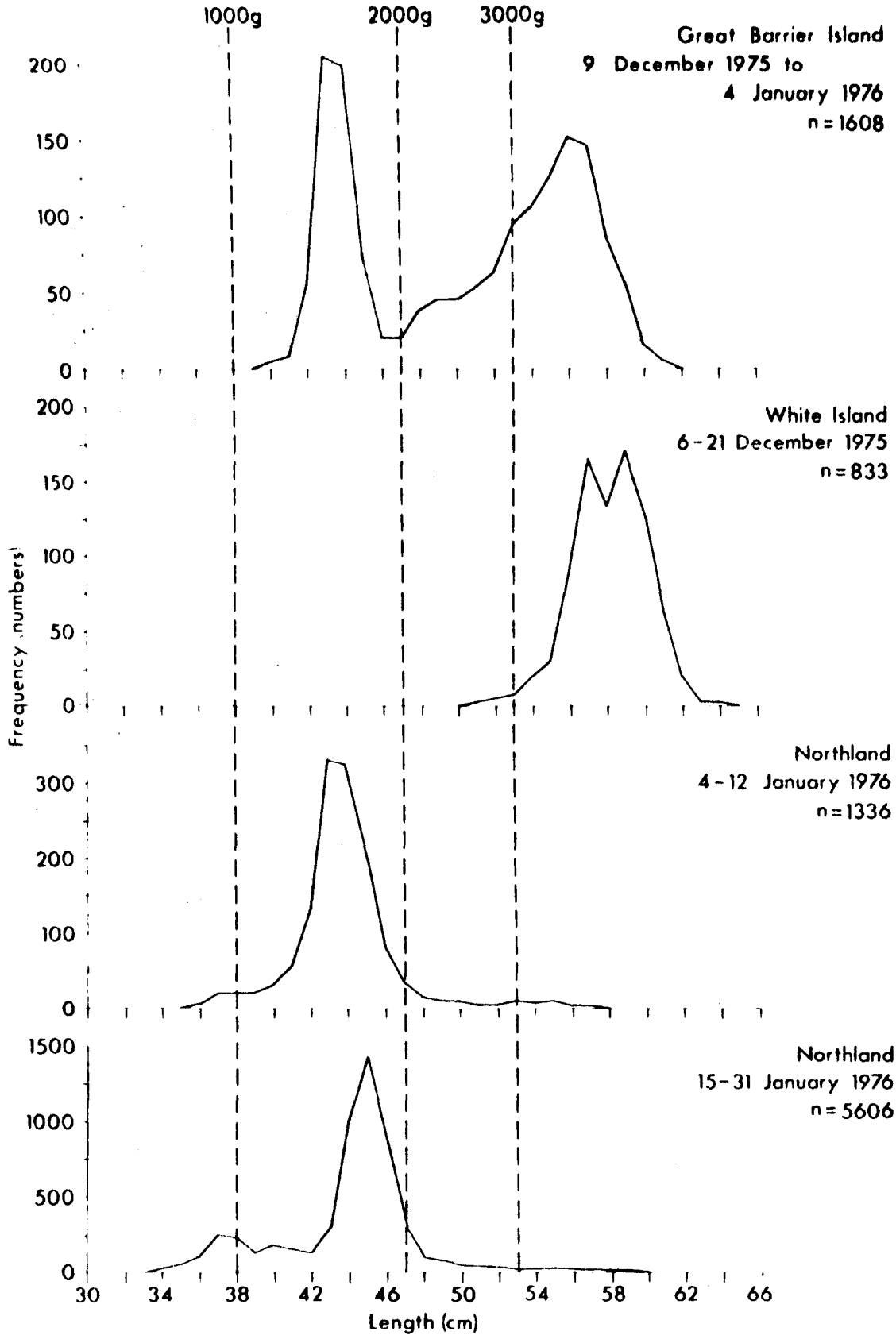
Fig. 4. Length-frequency distributions of skipjack tuna caught by the purse seiner Paramount off New Zealand in 1974 and 1975.

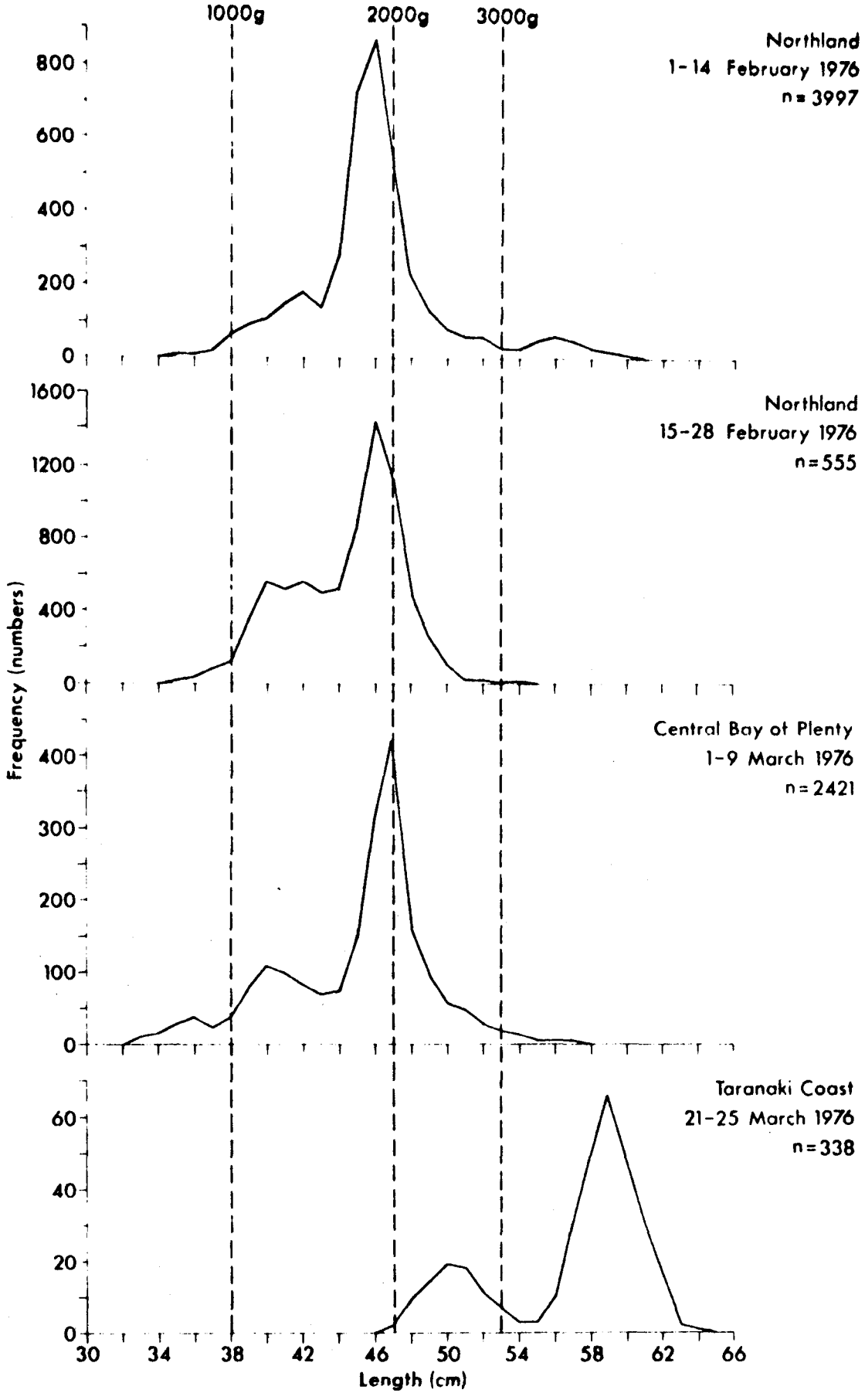
Fig. 5. Length-frequency distributions of skipjack tuna caught by two New Zealand purse seiners in January to February 1976.

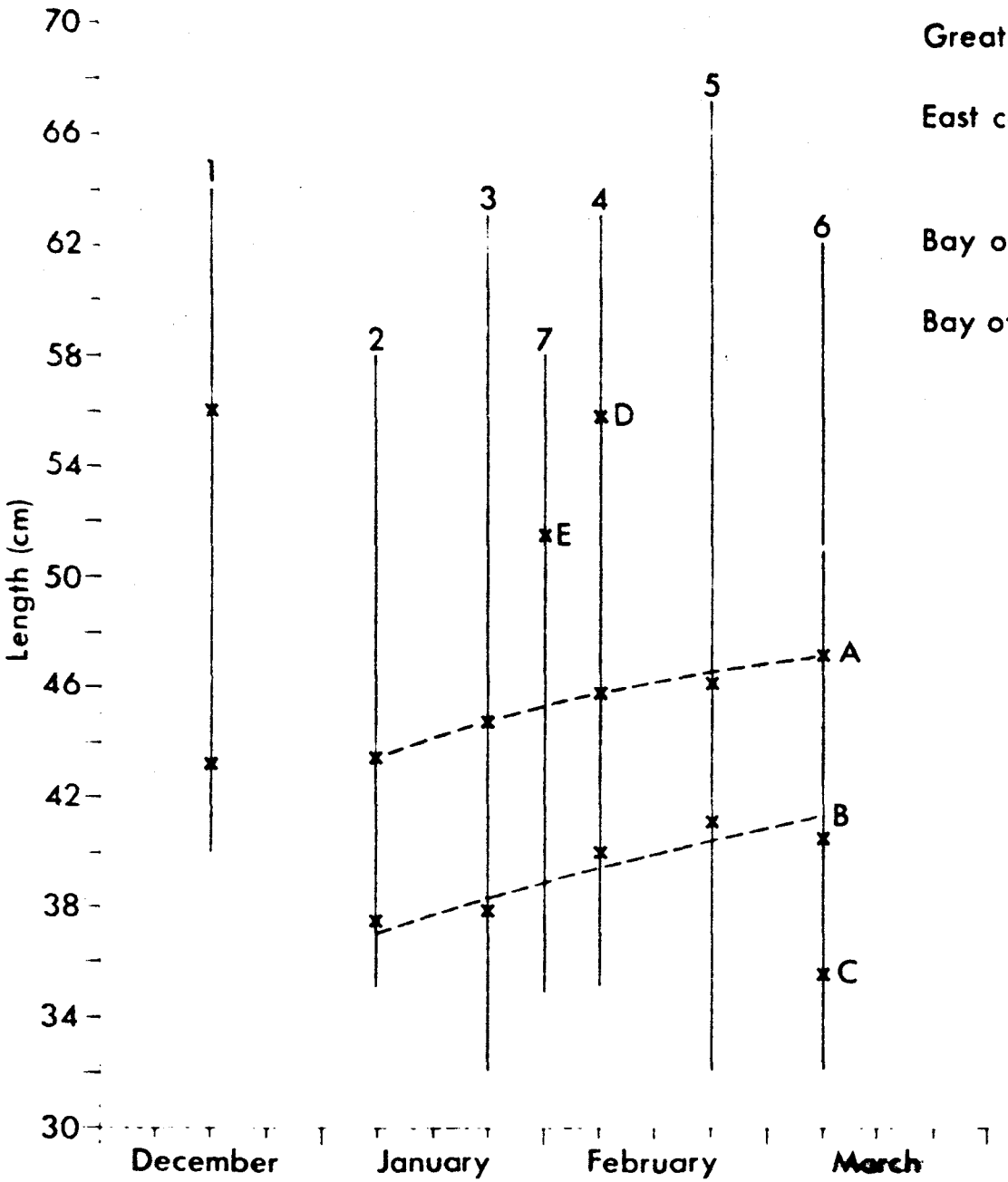
Fig. 6. Length-weight relationship of skipjack tuna caught off New Zealand by purse seine in March 1976, showing data points (mean weights of centimetre groups) and the fitted curve. The curve published by Chatwin (1959) for skipjack tuna from the eastern Pacific Ocean is also shown.

Fig. 7. Gonad weight plotted against body length of skipjack tuna caught off New Zealand by purse seine in March 1976.

Fig 1 Vooren Shifting of Modes




1000g
2000g
3000g
Northland
1-14 February 1976
n = 3997
Northland
15-28 February 1976
n = 555
Central Bay of Plenty
1-9 March 1976
n = 2421
Taranaki Coast
21-25 March 1976
n = 338
Frequency (numbers)
Length (cm)
0
200
400
600
800
1200
1600
100
300
20
40
60
30
34
38
42
46
50
54
58
62
66



Great Barrier Island, 1975 : 1

East coast of Northland, 1976 : 2 - 5

Bay of Plenty, 1976 : 6

Bay of Plenty, 1975 : 7

FIG 2 Hoover

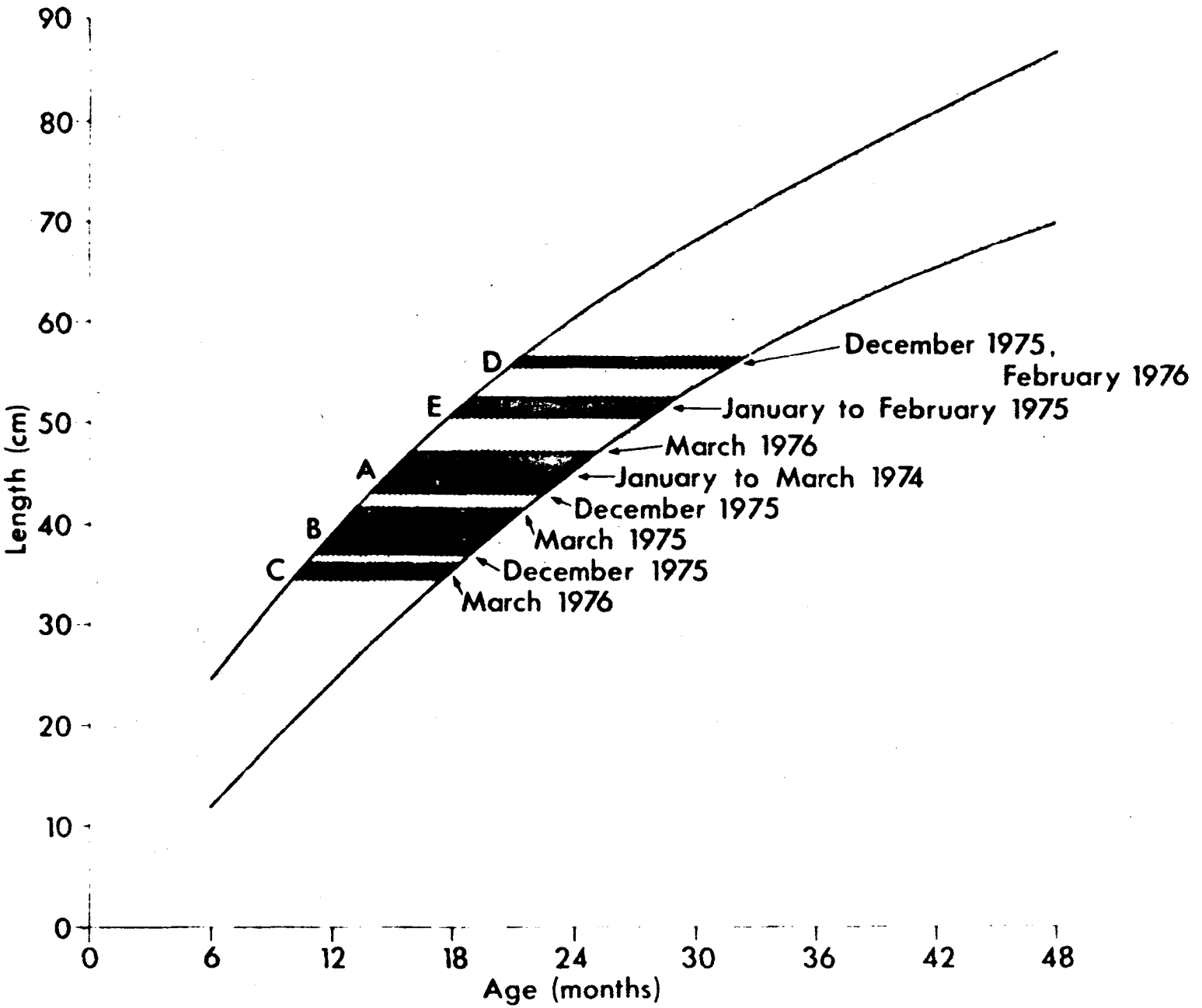

90
80
70
60
50
40
30
20
10
0
Length (cm)
0
6
12
18
24
30
36
42
48
Age (months)
D
E
A
B
C
December 1975,
February 1976
January to February 1975
March 1976
January to March 1974
December 1975
March 1975
December 1975
March 1976

Fig 3 Vogten

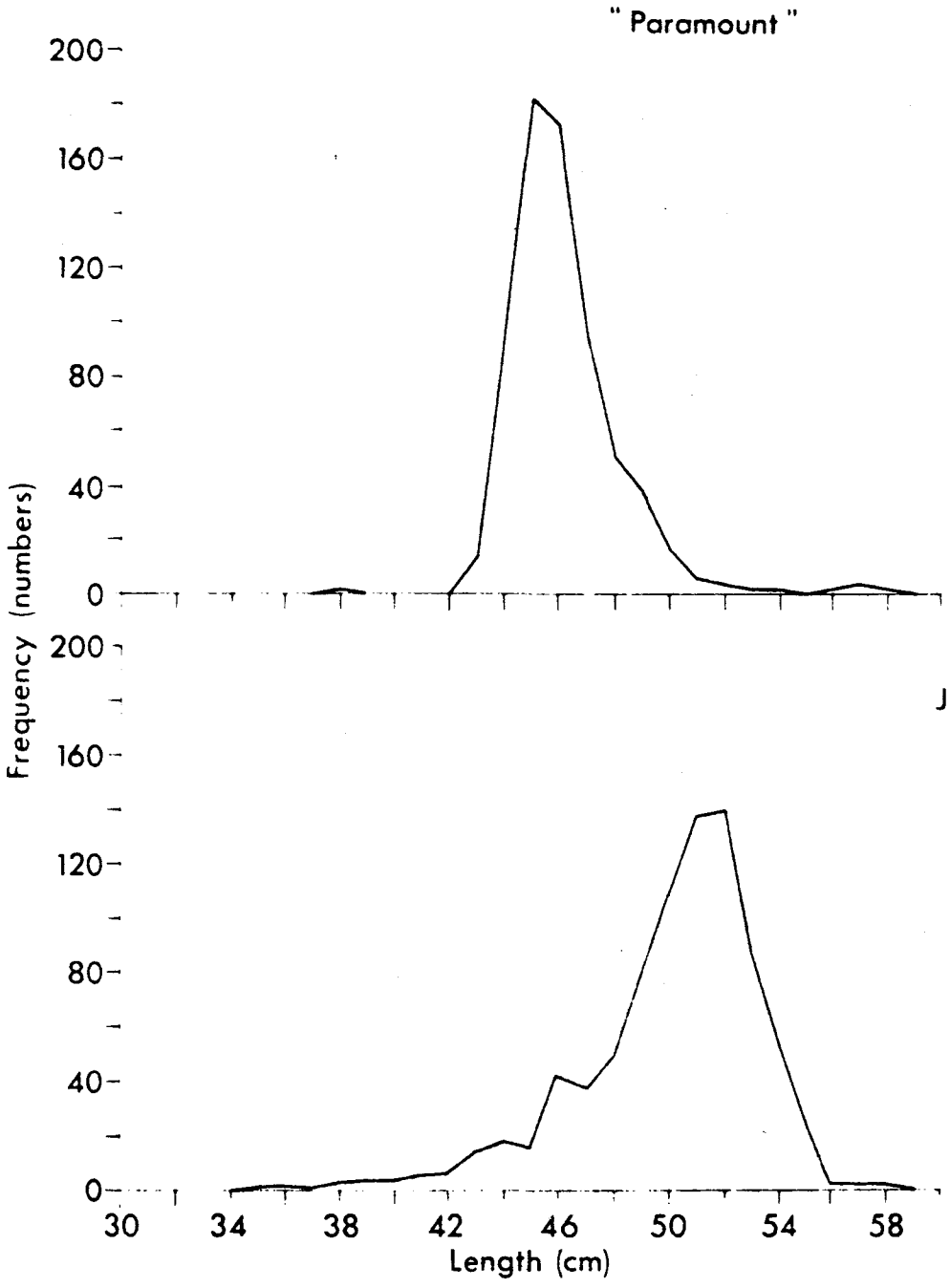
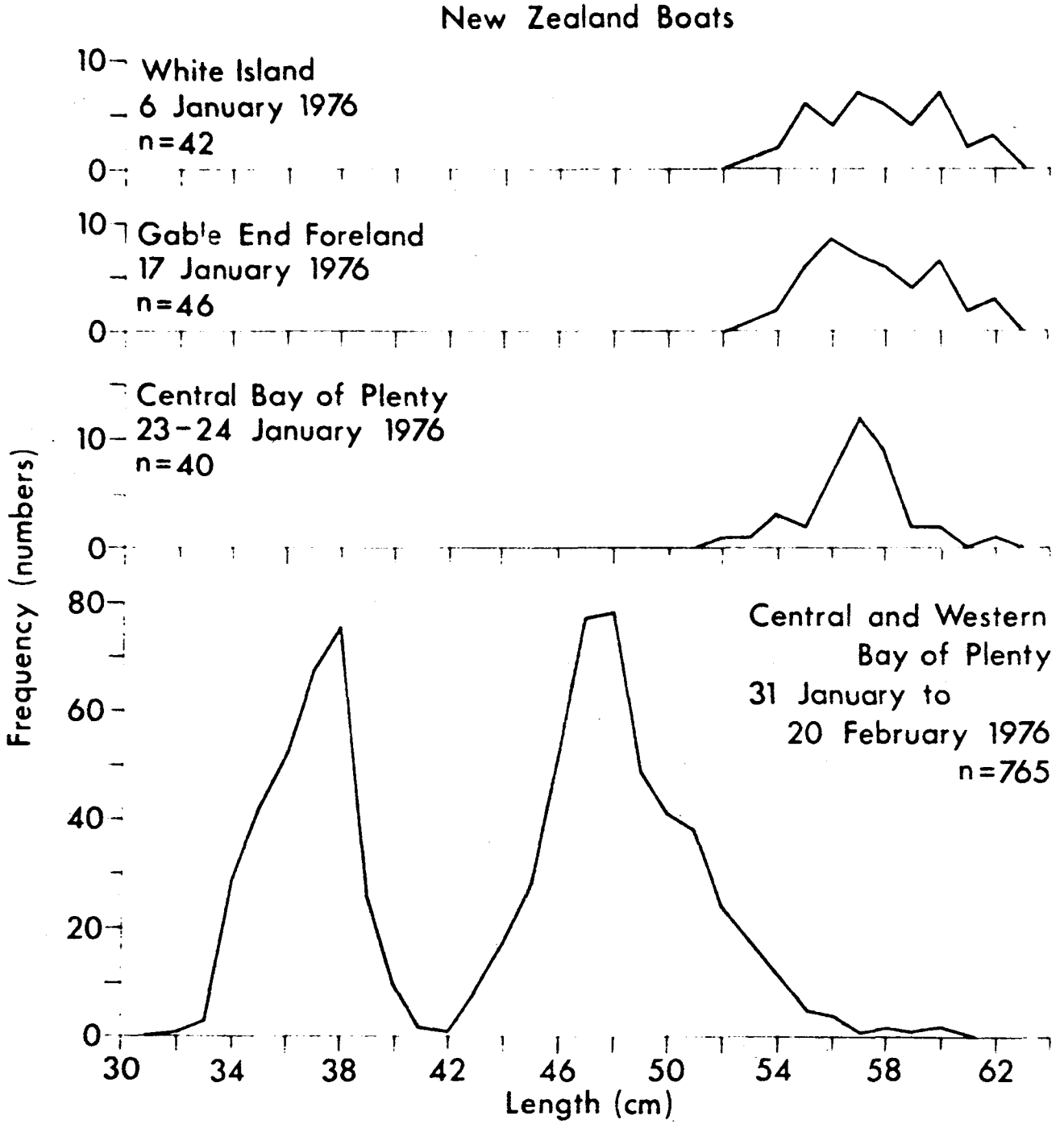


Fig 4

Voorter


New Zealand Boats
White Island
6 January 1976
n=42
Gable End Foreland
17 January 1976
n=46
Central Bay of Plenty
23-24 January 1976
n=40
Central and Western
Bay of Plenty
31 January to
20 February 1976
n=765
Frequency (numbers)
Length (cm)
0
10
20
40
60
80
30
34
38
42
46
50
54
58
62

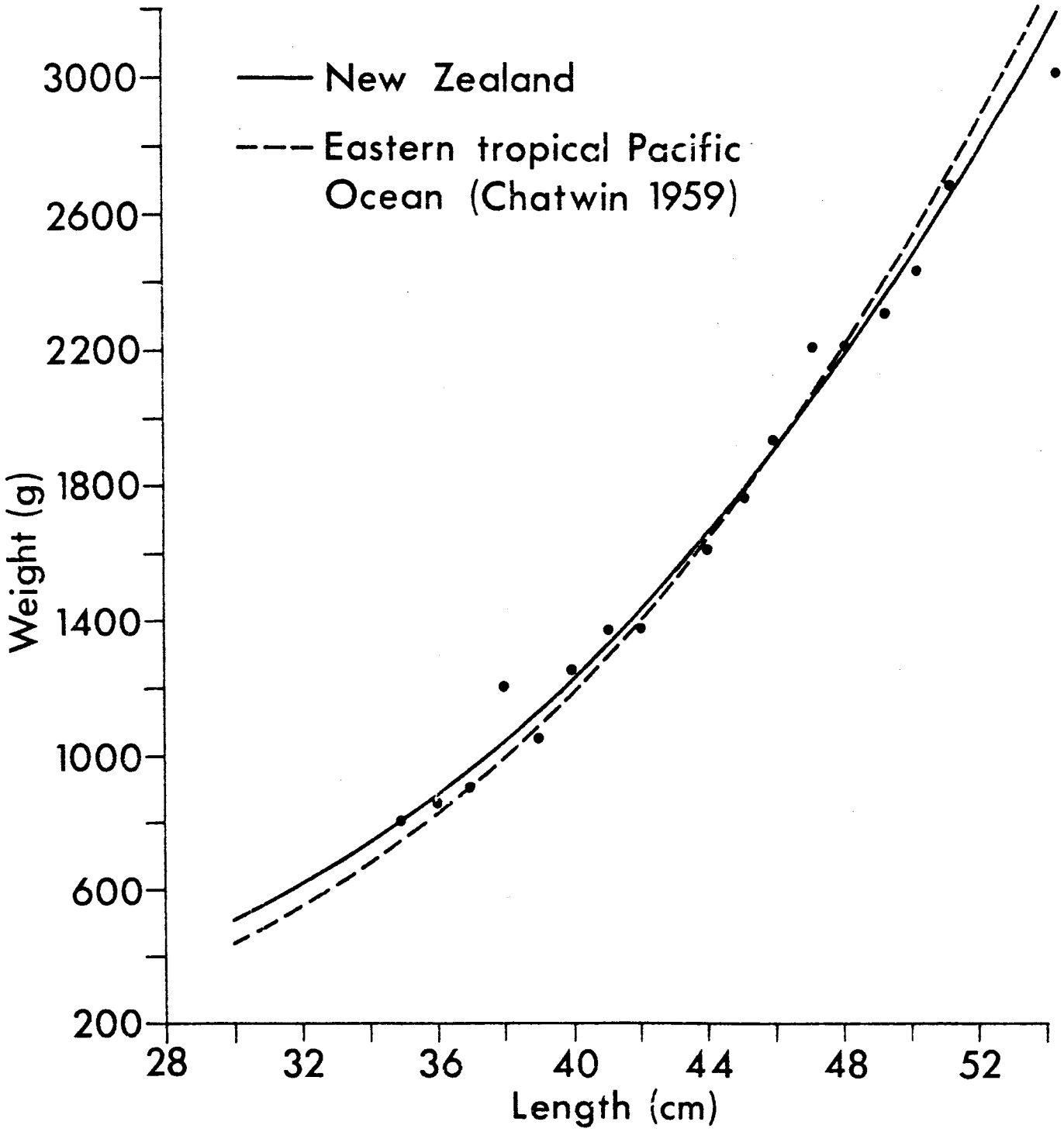
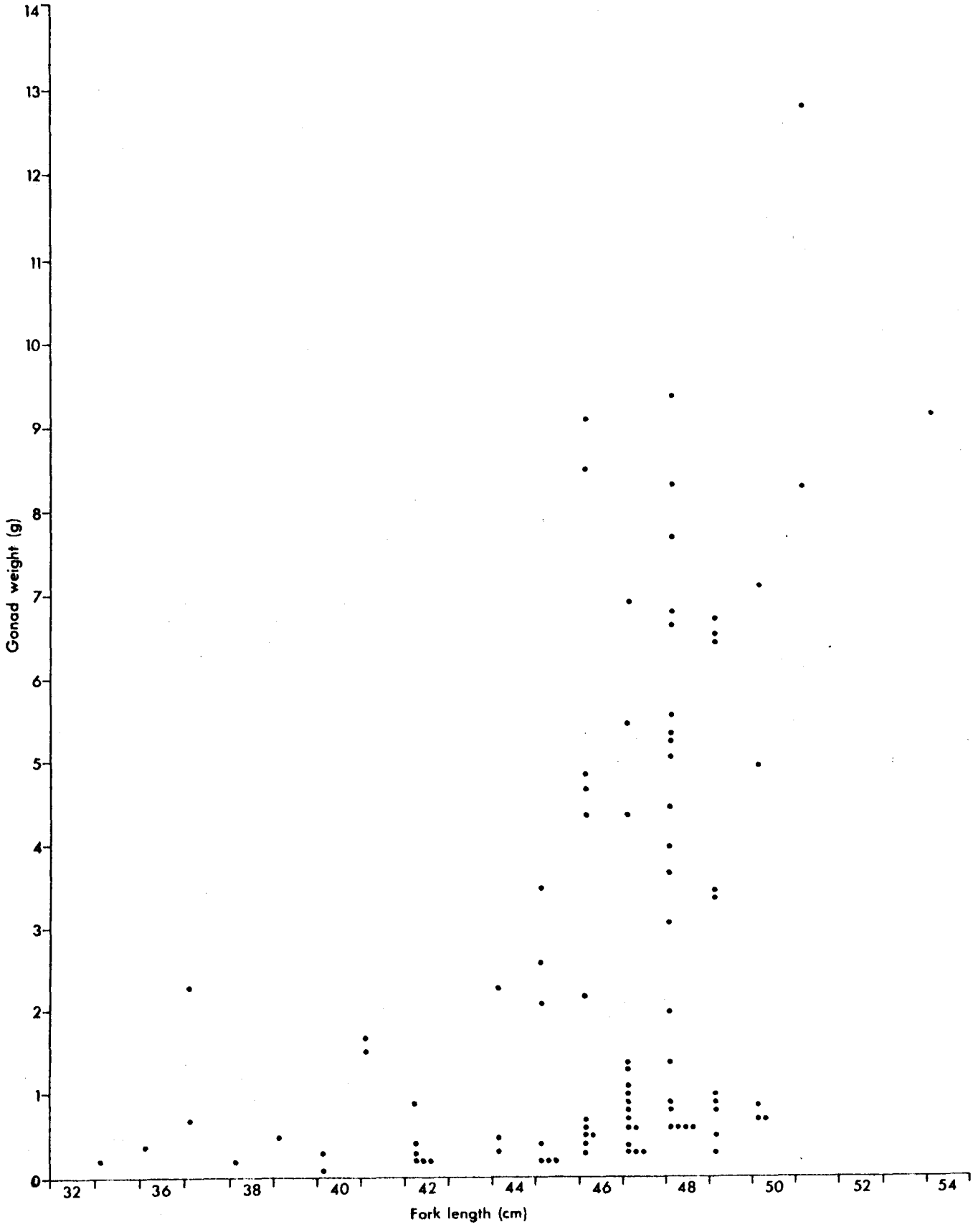

New Zealand
Eastern tropical Pacific Ocean (Chatwin 1959)
Weight (g)
3000
2600
2200
1800
1400
1000
600
200
28
32
36
40
44
48
52
Length (cm)

Fig 7. Vooren


Gonad weight (g)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
32
36
38
40
42
44
46
48
50
52
54
Fork length (cm)