"This paper not to be cited without prior reference to the author"

International Council for the Exploration of the Sea

C.M. 1975/J:3
Pelagic Fish (Southern) Committee

On the disappearance of bluefin tuna in the North Sea and its ecological implications on North Sea fish stocks *)

by

K. Tiews
Institut für Küsten- und Binnenfischerei
der Bundesforschungsanstalt für Fischerei,
Hamburg

*) This paper has been submitted also to the "Symposium on The Changes in the North Sea Fish Stocks and their Causes" in Aarhus, 9.-12. July 1975

International Council for the Exploration of the Sea

C.M. 1975:J:3
Pelagic Fish (Southern) Committee

On the disappearance of bluefin tuna in the North Sea and its ecological implications on North Sea fish stocks

by

K. Tiews
Institut für Küsten- und Binnenfischerei
der Bundesforschungsanstalt für Fischerei,
Hamburg

1. Introduction

The presence of bluefin tuna in the North Sea was known already during the last decades of the last century. Bluefin tuna landings from the Central North Sea were recorded then in the beginning of this century from French fishermen as early as 1907 and later on from Swedish fishermen and others (9). But the fishery on bluefin tuna was usually a side fishery in connection with herring fishery or a game fishery until the 2nd world war. A systematic bluefin tuna fishery developed only after the 2nd world war with purseines on the Norwegian coast, with hook and line in Denmark, Sweden and the Federal Republic of Germany. During the years from 1951-1962 the bluefin tuna fishery in the North Sea yielded catches between 2 600 and 10 600 tons (Tables 1-2). With the exception of 1965, when again 2 500 tons bluefin tuna were landed from the North Sea on the Norwegian coast, the fishery sharply declined after 1962. Denmark and the Federal Republic of Germany had to cease their full time bluefin tuna fishery due to unvailability of bluefin tuna in the Central North Sea. Sweden discontinued her fishery already in 1956 for economic reasons.

Table 1: Bluefin tuna catches in ICES statistical areas II a, III a, IV a, IV b during 1951-1972 in 1 000 tons (according to Bluefin Tuna Working Group Reports)

Year	II a in 1000 t	II a in % of total	IV a in 1000 t	IV a in % of total	IV b + III a in 1000 t	IV b + III a in % of total	Total in 1000 t
1951	2.6	38.2	2.6	38.2	1.6	23.6	6.8
1952	3.5	24.8	8.0	56.8	2.6	18.4	14.1
1953	1.8	20.0	6.1	67.8	1.1	12.2	9.0
1954	6.0	54.0	3.5	31.5	1.6	14.4	11.1
1955	3.2	25.1	7.2	56.7	2.3	18.1	12.7
1956	1.3	25.4	2.8	55.0	1.0	19.6	5.1
1957	1.3	18.8	3.7	54.9	1.9	27.6	6.9
1958	1.0	27.7	2.0	55.6	0.6	16.7	3.6
1959	0.5	11.6	2.0	46.6	1.8	41.9	4.3
1960	0.4	10.8	2.9	78.4	0.4	10.8	3.7
1961	1.1	15.2	5.6	77.8	0.5	6.9	7.2
1962	3.4	39.5	4.8	55.8	0.4	4.7	8.6
1963	0.0	50.0	0.2	100.0	0.0	0.0	0.2
1964	0.0	0.0	1.6	100.0	0.0	0.0	1.6
1965	0.0	0.0	2.5	100.0	0.0	0.0	2.5
1966	0.0	0.0	1.0	100.0	0.0	0.0	1.0
1967	0.0	0.0	1.9	100.0	0.0	0.0	1.9
1968	0.0	0.0	0.9	100.0	0.0	0.0	0.9
1969	0.0	0.0	0.9	100.0	0.0	0.0	0.9
1970	0.0	0.0	0.4	100.0	0.0	0.0	0.4
1971	0.0	0.0	0.6	100.0	0.0	0.0	0.6
1972	0.0	0.0	0.1	100.0	0.0	0.0	0.1

Table 2: Bluefin tuna catches from the North Sea (51°N - 62°N) by countries in 1 000 tons during 1950- 1972 (according to Bluefin Tuna Working Group Reports)

Year	Norway	Sweden	Denmark	Germany (Fed.Rep. of)	Total
1950	0.3	0.1	1.0	0.2	1.6
1951	2.6	0.2	1.2	0.2	4.2
1952	8.0	0.2	2.1	0.3	10.5
1953	6.1	0.0	0.8	0.3	7.2
1954	3.5	0.1	0.9	0.6	5.1
1955	7.2	0.1	1.1	1.1	9.5
1956	2.8	0.0	0.4	0.6	3.8
1957	3.7	0.0	0.6	1.3	5.6
1958	2.0	0.0	0.2	0.4	2.6
1959	2.0	0.0	0.8	1.0	3.8
1960	2.9	-	0.0	0.4	3.3
1961	4.6	0.0	0.2	0.3	5.1
1962	4.8	-	0.2	0.2	5.2
1963	0.2	-	0.0	0.0	1.0
1964	1.6	-	0.1	0.0	1.7
1965	2.5	-	0.0	0.0	2.5
1966	1.0	-	0.0	0.0	1.0
1967	1.9	-	0.0	-	1.9
1968	0.9	-	0.0	0.0	0.9
1969	0.9	-	0.0	0.0	0.9
1970	0.4	-	0.0	0.0	0.4
1971	0.6	-	0.0	0.0	0.6
1972	0.1	-	0.0	0.0	0.1

The aim of this contribution is to describe the reason for the disappearance of the bluefin tuna from the Central North Sea and to attempt to assess the major ecological implication resulting from it. Since the bluefin tuna has to be considered as an important fish predator during its stay in the North Sea, it is tried to calculate the total loss which North Sea fish stocks likely may have suffered from 1951-1972 through the bluefin tuna.

When discussing the bluefin tuna situation in the North Sea, reference is made to the various reports of the Bluefin Tuna Working Group of ICES (1,3-6) which was set up following a recommendation of the Scombriform Fish Committee of ICES in 1961. The main task of this Working Group was and still is to compile uniformly all bluefin tuna catch composition data from the ICES area, in order to establish the relationship between the occurrences of the bluefin tuna in the different areas of its distribution range and the timing of arrival of the fish.

2. Relationship of bluefin tuna occurrences on the Norwegian coast and the Central North Sea during 1956-1962

In order to study the relationship of bluefin tuna occurrences observed on the Norwegian coast and in the Central North Sea, the Bluefin Tuna Working Group compiled length composition data of bluefin tuna catches made on the Norwegian west coast south of 62°N, on the Norwegian coast north of 63°N and on the fishing grounds from the Central North Sea on a weekly basis. Examples of such an analysis are given in Fig. 1 and 2 for the years 1961 and 1957.

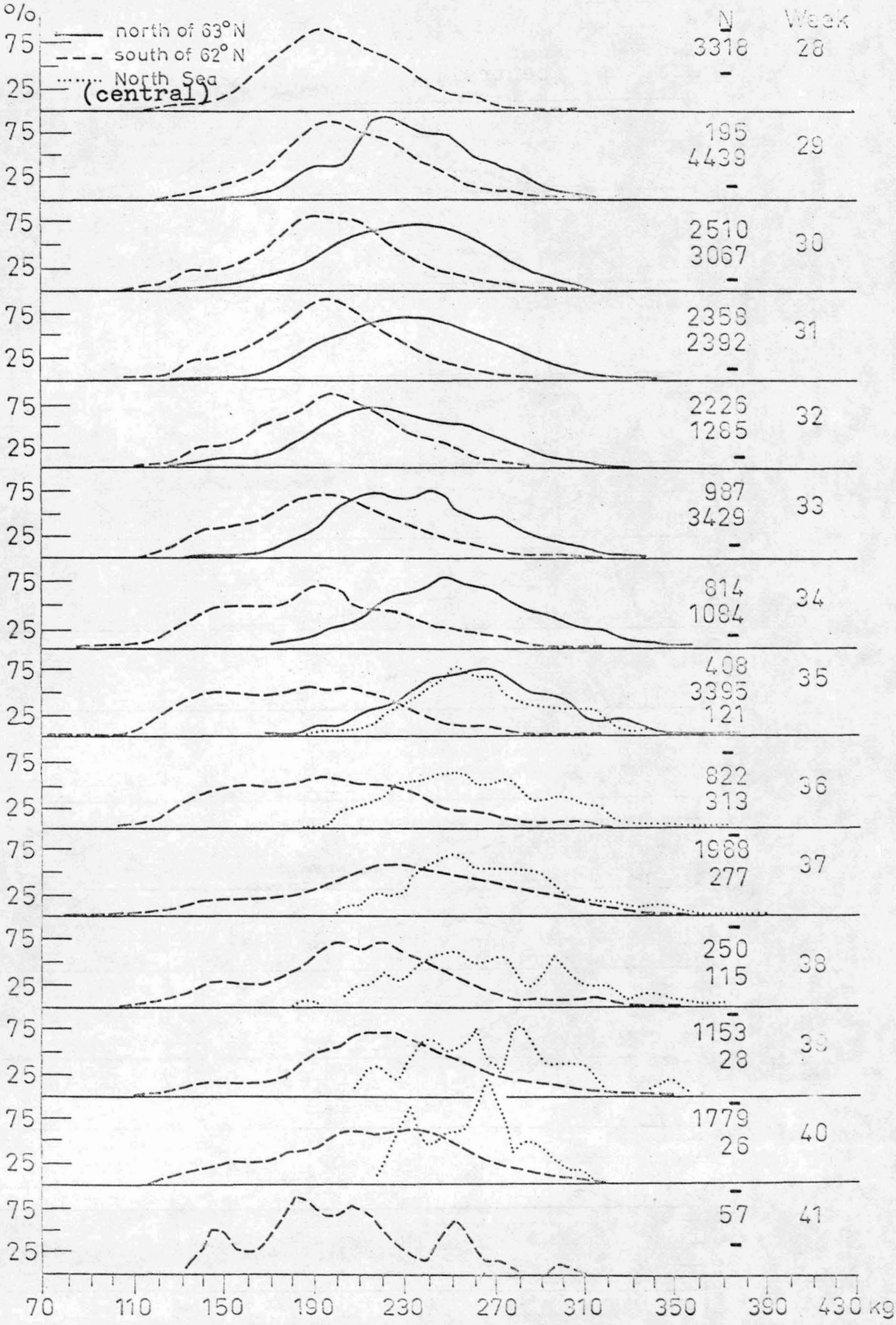

Fig.1: Size composition of Norwegian and German bluefin tuna catches by areas and weeks in 1961. (6)

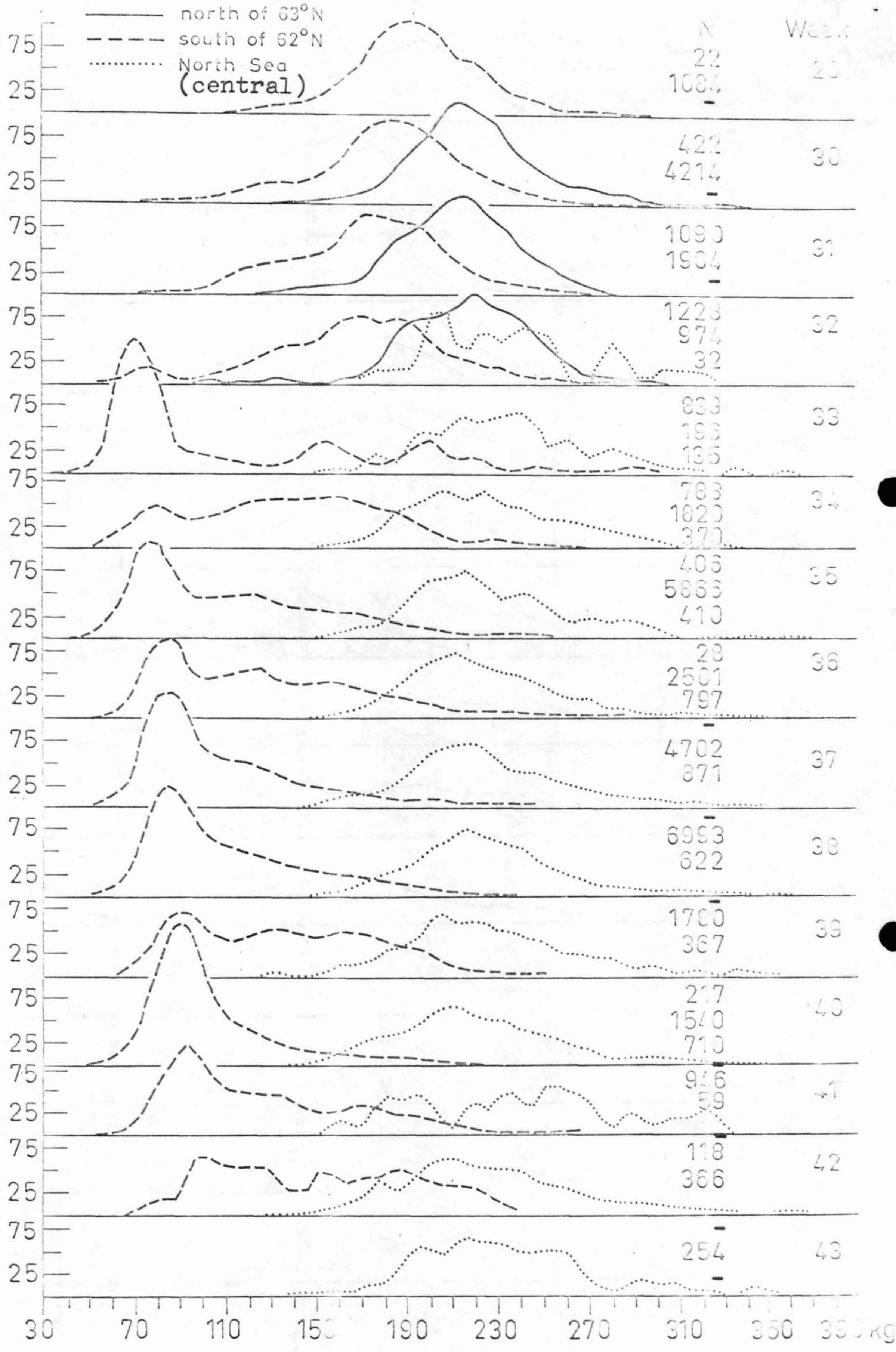

Fig.2: Size composition of Norwegian and German bluefin tuna catches by areas and weeks in 1957. (6)

In 1961, the largest fish having a mode in their weight distribution curves at around 220 kg arrived in week 29 on the north Norwegian coast. During the next three weeks more than 7 000 fish were caught. During the 33rd to 35th week the catch decreased steadily, and when the tuna fishery terminated on the north Norwegian coast, bluefin tuna of the same size composition began to appear in the fishing localities in the Central North Sea. It may be noted that there are about 4 weeks between the first sign of emigration of tuna from the north Norwegian coast and the occurrence of tuna in the Central North Sea, and a similar period between the peaks of fishing season for the two areas. On the other hand, no evidence is given that the tuna occurring on the Norwegian coast south of 62°N are continuing their migration to the Central North Sea. In all the years under observation they remained in their typical size composition there until the end of their fishing season , which normally terminated in the weeks 41-43. During 1957 the largest fish were caught only for 3 weeks on the north Norwegian coast and arrived already 3 weeks earlier in the Central North Sea (Fig. 2). But again there was a time lag of 4 weeks between the peaks of the fishing season.

In Fig. 3 the assumed migration routes of bluefin tuna during their stay in the northeast Atlantic in the years 1956-1962 were drawn. The unbroken line describes the migration route of a 12-14 years' old tuna, the broken line of a medium old fish and the dotted line of the smallest fish, which have entered in these years together with the medium old fish occasionally also the Kattegat. The figures in the drawing indicate the position of the German fishing grounds in the Central North Sea.

During the period under observation from 1956-1962 it was typical that the Norwegian catches consisted of several runs of tuna with distinct differences in their age composition (Fig. 4). Several of the age groups can be followed as modes

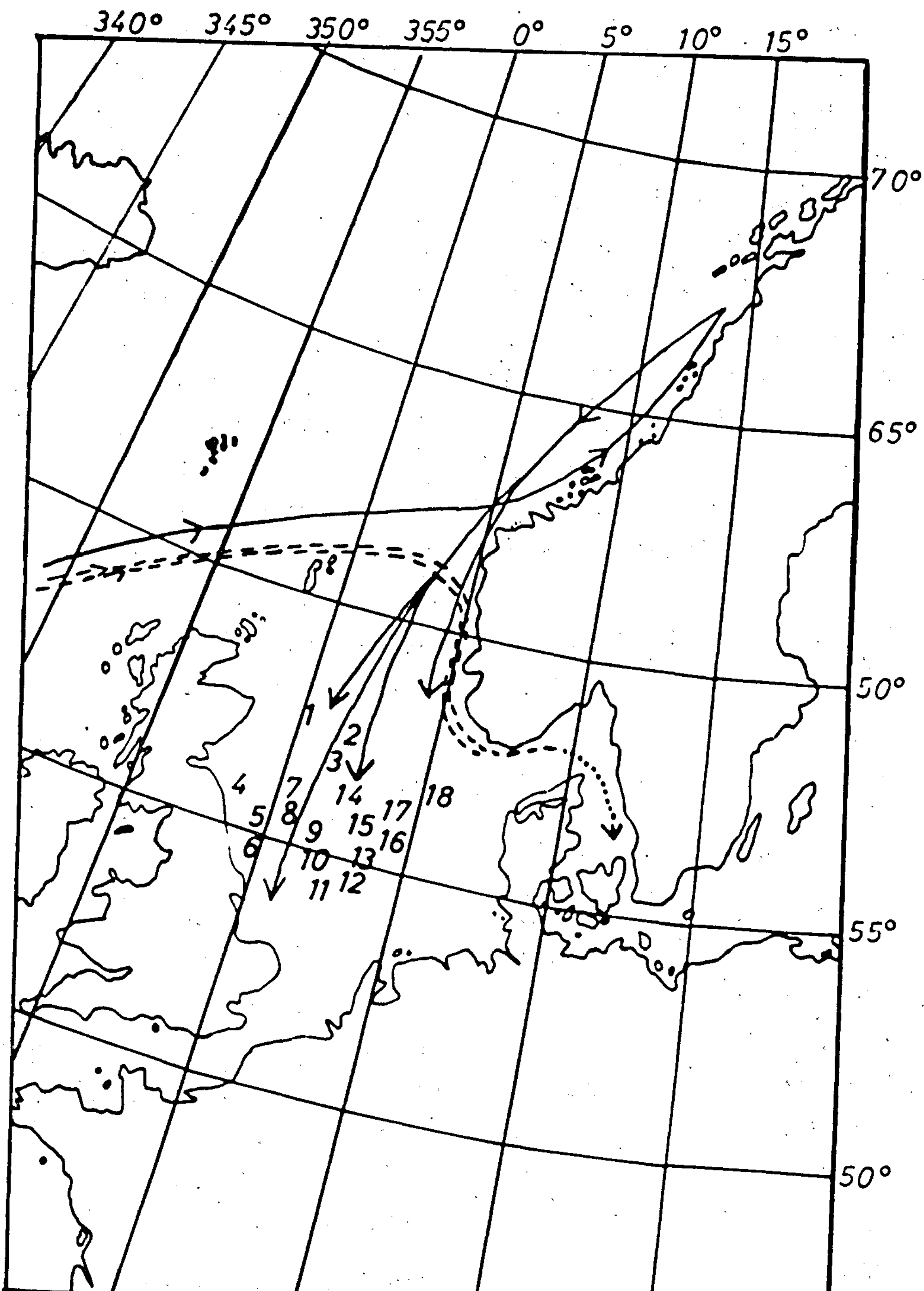

Fig. 3: Assumed migration routes of bluefin tuna during stay in North European waters during 1956-1962(12). Unbroken lines refer to 12-14 years' old fish, broken lines to younger fish. The numbers refer to position of German fishing places:

1 = Fladengrund; 2 = Gat; 3 = Devils Hole; 4 = Farn Deeps; 5 = Baymans Loch; 6 = Whitby Grund; 7 = Ostbank/Nordost-Bänke; 8 = Bruceys Garden; 9 = Dogger-Süd-Riff; 10 = Bolders Bank; 11 = Well-Bank; 12 = Outer-Silver Pitt; 13 = Süd-Riff; 14 = Mittel-Riff; 15 = Ellbogen; 16 = Südl. Schillgrund; 17 = Tail End; 18 = Kaffeesuhle.

in the length frequency distribution curves over several years. The last two rich year classes observed on the Norwegian coast were those of 1950 and 1952, occurring on the Norwegian coast for the first time in 1956 resp. 1958.

Looking to Fig. 4, it becomes obvious that the bluefin tuna fishery in the Central North Sea terminated exactly then in 1963, when only 1 run instead of 2,3 or even more runs of different old fish, as observed in the former years, arrived on the Norwegian coast. 1963 was not only the end of the fishery in the Central North Sea, but practically also the end of the north Norwegian tuna fishery. It seems, as if the migration coverage of the bluefin tuna in the northeast Atlantic is related to the size composition of the fish. If only one distinct group of fish arrives on the west Norwegian coast, it continues to stay there south of 62°N until the end of the fishing season. There is reason to believe that it needs at least two runs of tuna of different age to keep the migration go round of the oldest fish moving. During the years from 1963-1972 few of the fish arriving on the west Norwegian coast went also to the Kattegat, as catches of Danish fishermen indicate.

It is the lack of recruit year classes to the northeast Atlantic tuna fishery which caused the absence of bluefin tuna in the Central North Sea after 1962. It is believed that the last incoming recruit year class 1952, which occurred for the first time in 1958 on the Norwegian west coast, determined the bluefin tuna catches over many years from 1965 to 1971. The size composition of the west Norwegian catches changed then relatively little, as the fish had more or less reached its ultimate length. That fish do indeed follow the same migration pattern over many years shows also the recapture of a fish in 1970 which had been tagged in 1962 on the west Norwegian coast. (Table 3).

It is also obvious from what has been stated that the discontinuation of the bluefin tuna fishery in the Central North Sea is not caused by overfishing the stock in the North Sea itself.

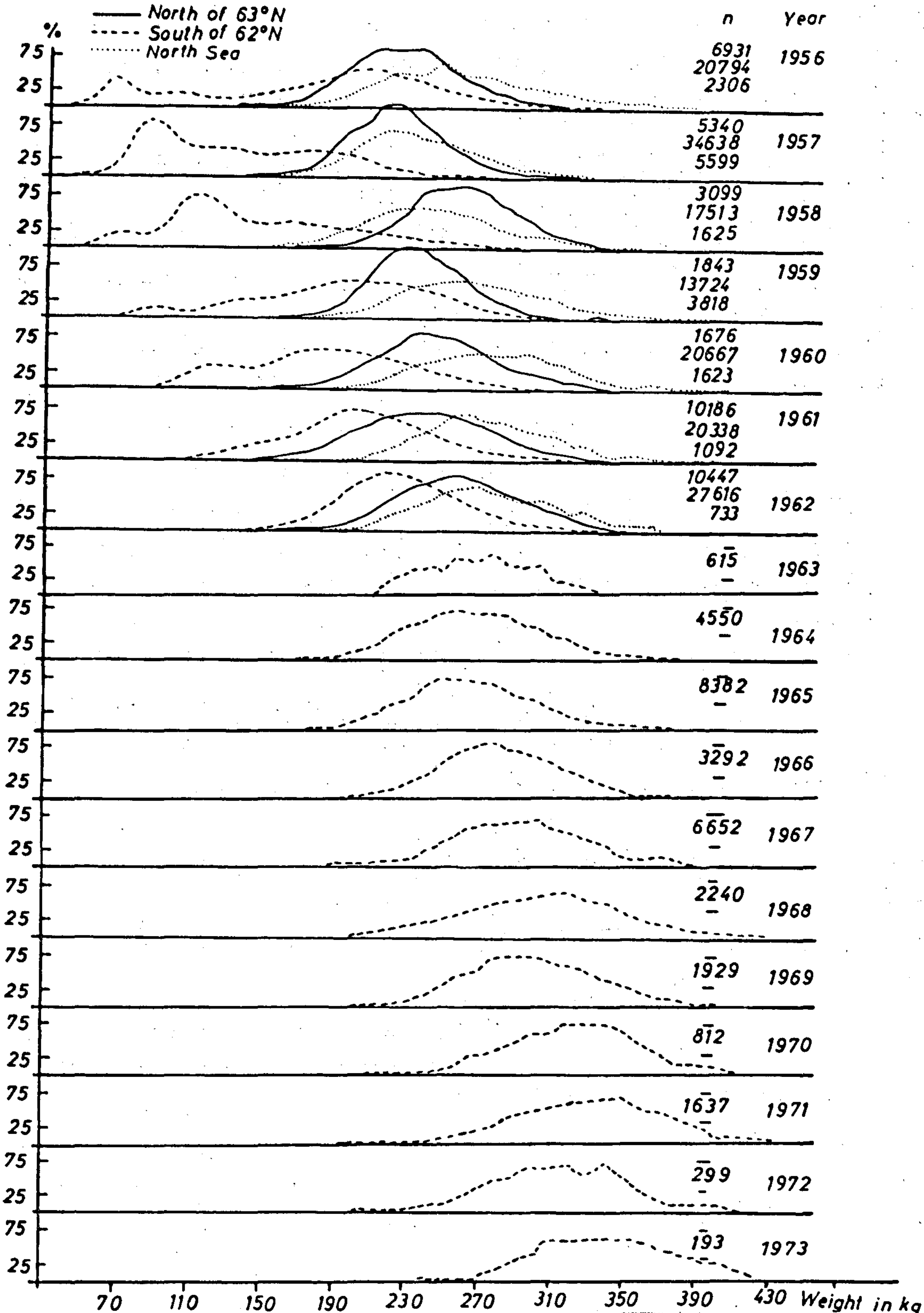

Fig.4: Size composition of Norwegian and German Bluefin tuna catches by areas in the years 1956-1973 (according to Bluefin Tuna Working Group Reports)

Table 3: Releases of bluefin tuna in coastal waters of west Norway, and returns by years and area(1)

Releases		Coast of Norway/North Sea Years at large										Coast of Spain Years at large										Grand Total
Year	No.	0	1	2	3	4	5	6	7	8	Total	0	1	2	3	4	5	6	7	8	Total	
1957	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	20	0	1	0	0	0	0	0	1	0	2	0	3	0	0	0	0	0	0	0	3	5
1959	41	5	2	2	0	0	0	0	0	0	9	0	1	0	0	0	0	0	0	0	1	10
1960	64	1	4	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	1	6
1961	81	3	2	1	0	0	1	1	0	0	8	0	0	0	0	1	0	0	0	0	1	9
1962	13	0	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	2
Total	242	9	9	3	1	0	1	1	1	1	26	0	4	1	0	1	0	0	0	0	6	32

3. Prey-fish consumption of bluefin tuna during their stay in the North Sea

In the following it shall be attempted to calculate the prey-fish consumption of bluefin tuna during their stay in the North Sea during the years 1951-1972. In order to do this, certain assumptions and considerations have to be made.

Prey-fish consumption shall be calculated for the tuna population during its stay in the entire northeast Atlantic, and not for the North Sea only. Looking to Table 1, it can be concluded that in most of the years most of the catches were taken in ICES statistical areas IV a and IV b, i.e. in the North Sea. Only in 1954 54.0 % were taken in area II a, in 1962 39.5 %, in 1951 38,2 %. In all other years less than 30 % of the total catch was taken in area II a. But even then it has to be considered that the stock of tuna fished upon in area II a stood there only 3 to 6 weeks and proceeded from there to the Central North Sea. This means that much of the preying of these old tuna was done in the area covered by the North Sea.

Because of the absence of any better suitable parameter to estimate the size of the total population of bluefin tuna, which was present in the northeast Atlantic waters, catch was used as abundance index. Total population size of the tuna present was estimated under the assumption of a fishing mortality of 10 %. A certain justification for doing this can be conclueded from Table 3 on the releases of bluefin tuna in coastal waters of west Norway and returns by years and area. According to these data forwarded by Hamre to the Bluefin Tuna Working Group (5), some 7.4 % of bluefin tuna tagged in coastal waters of west Norway were recaught roughly within one year on an average of a 6 years' period. The total return rate over a period of 8 years after tagging accumulated to 10.7%. The total population size is expressed in number of fish weighing on an average 200 kg each for the period 1951-1962 and weighing 300 kg each for the period of 1963-1972. It was calculated by multiplying the catch figures with 10.

Alternative calculations were made on the basis of a fishing mortality of 20 % and of 33.3 % in Table 6. Then the feed fish requirement for bluefin tuna of various sizes during their stay in the North Sea had to be estimated. Bluefin tuna sizes of 100 kg, 200 kg and 300 kg were selected. Tiews (12) has shown that the mean condition factor K for bluefin tuna, caught by German fishermen from 1954-1961, has increased during their stay in the Central North Sea by 0.11 (Table 4).

The necessary examination of the question, whether a correlation exists between the K factor and the length of the bluefin tuna, could be denied for the length groups in question (Fig. 5). The variation of the K factor for the bluefin tuna caught in the Central North Sea by German fishermen is shown in Fig. 6. In some years two moded distribution curves were obtained, indicating the immigration of very light tuna which might just have crossed the Atlantic Ocean prior to their arrival in the North Sea as described by Tiews (12).

Hamre in his contributions to the Bluefin Tuna Working Group Reports demonstrates increases of K during the stay of bluefin tuna on the west Norwegian coast up to 0.3. In Table 5 the weight gain through the improvement of the condition factor has been calculated for the 3 size groups of tuna selected, assuming 3 different condition factor increases, i.e., 0.1, 0.2 and 0.3. Another weight gain of the bluefin tuna can be expected from its potential annual growth during its roughly 100 days' stay in the northeast Atlantic. This weight gain has been calculated on the basis of 1/3 of the annual growth. The sum of these two weight gains gives the total weight gain, as indicated in Table 5.

Table 4: Mean condition factor K for bluefin tuna caught by German fishermen in the Central North Sea (12).

Month	1954	1955	1956	1957	1958	1959	1960	1961
August	1.69	1.81	1.78	1.74	1.82	1.81	1.78	1.75
Sept.	1.65	1.74	1.91	1.77	1.84	1.83	1.88	1.75
Oct.	1.72	1.89	1.96	1.84	1.88	1.93	1.90	1.83

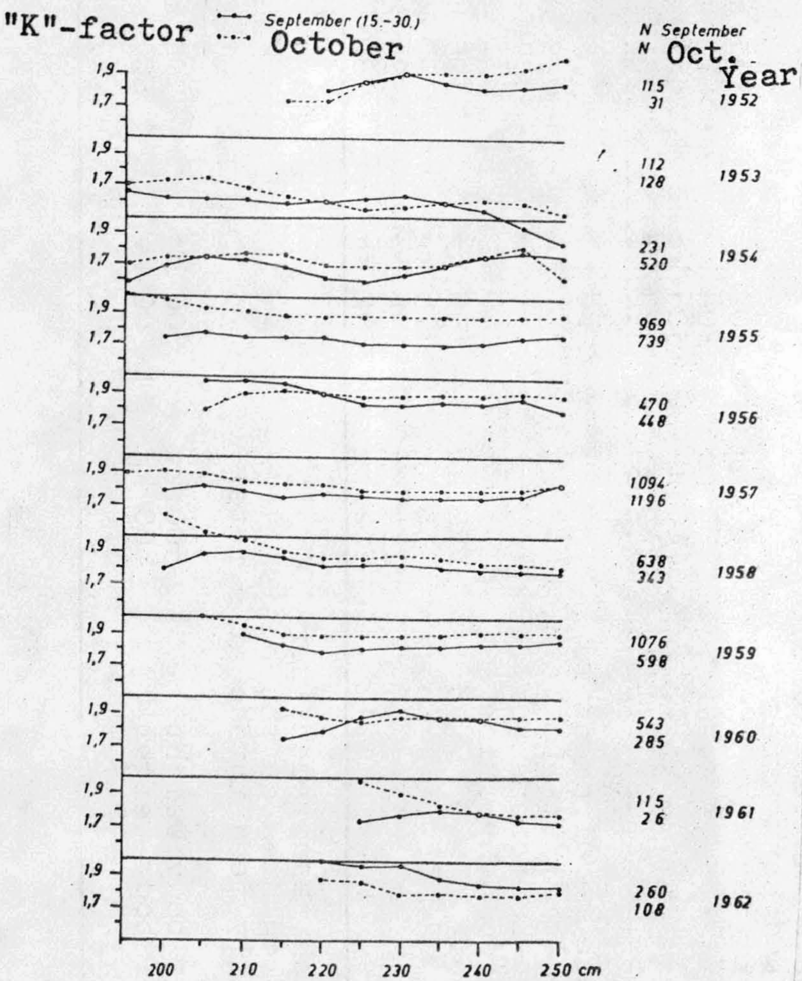

Fig.5: Relationship between K-factor and length of 9-15 years old bluefin tuna during stay in the Central North Sea for the years 1952-1962(12)

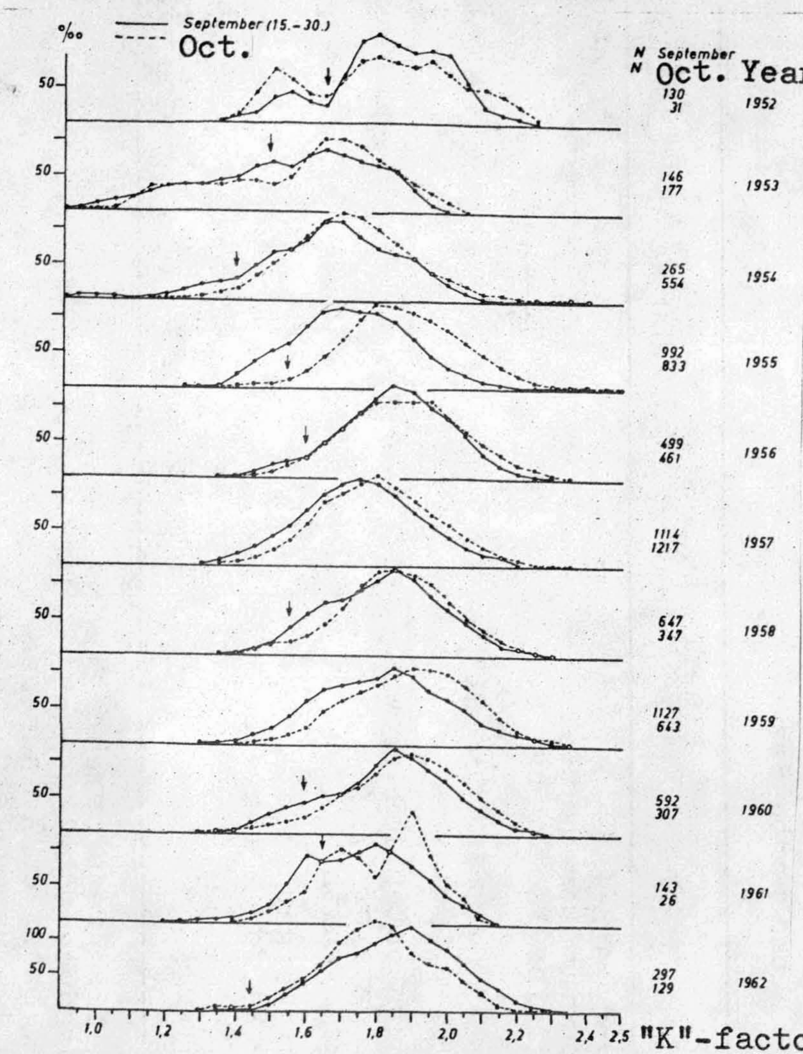

Fig.6: Frequency distribution of K-factor for 9-15 years old bluefin tuna during stay in the Central North Sea for the years 1952-1962 (12)

Table 5: Estimate of feed fish requirement of bluefin tuna of various sizes under various assumptions during stay in the North Sea

		Bluefin tuna size 100 kg	200 kg	300 kg
Weight gain (1) through improvement of condition factor by	0.1	6 kg	12 kg	18 kg
	0.2	12 kg	24 kg	36 kg
	0.3	18 kg	36 kg	54 kg
Weight gain (2) through potential growth at a rate of 1/3 of annual growth		8 kg	10 kg	11 kg
Total weight gain (1 + 2) for K increase by	0.1	14 kg	22 kg	29 kg
	0.2	20 kg	34 kg	47 kg
	0.3	26 kg	46 kg	65 kg
Feed fish requirement to produce total weight gain, based on K increase of 0,1 , using feed conversion rates of	3	42 kg	66 kg	87 kg
	6	84 kg	132 kg	174 kg
	9	126 kg	198 kg	261 kg
	12	168 kg	264 kg	348 kg
Feed fish requirement to produce total weight gain, based on K increase of 0.2, using feed conversion rates of	3	60 kg	102 kg	141 kg
	6	120 kg	204 kg	282 kg
	9	180 kg	306 kg	423 kg
	12	240 kg	408 kg	564 kg
Feed fish requirement to produce total weight gain, based on K increase of 0.3, using feed conversion rates of	3	78 kg	138 kg	195 kg
	6	156 kg	276 kg	390 kg
	9	234 kg	414 kg	585 kg
	12	712 kg	552 kg	780 kg
Feed fish requirement per 100 days calculated on the basis of a daily feed intake at a rate of				
3 % of body weight		300 kg	600 kg	900 kg
6 % of body weight		600 kg	1 200 kg	1 800 kg

Bahr (2) investigating bluefin tuna from the Central North Sea reports for giant tuna an average increase of 70 kg during their 2 1/2 months' stay there. Lühmann (8) estimated the total weight increase during the stay of tuna in the Central North Sea to be between 25 and 39 kg for the age groups VIII-XIV. These estimates fall within the range of estimates given in Table 5.

As a next step the feed fish requirement to produce the total weight gain based on various assumptions of K increase and of feed conversion rates, i.e. 3, 6, 9 and 12, was calculated (Table 5). The best estimates of feed conversion rates are known from commercialized fish feeding, such as of trouts and carps. A feed conversion rate of 3, calculated on fresh fish consumption, corresponds roughly to a pellet feed conversion of 1 in trout feeding, which is the best conversion rate so far obtained in systematic feeding experiments with trouts carried out at the Institut für Küsten- und Binnenfischerei in its program to develop optimal feeds for trout farming (7). A feed conversion rate of 6 corresponds respectively to a pellet feed conversion of 2 in trout farming, which is a reasonable conversion rate and achieved with most of the fish feeds in commercial use. In eel feeding experiments of the Institut für Küsten- und Binnenfischerei, fresh fish conversion rates of 9-12 have been achieved and found to be reasonable. A conversion rate of 9, recalculated from pellet feed consumption, has been found in carp feeding experiments of the same institute.

Finally, in a different approach the feed fish requirement per 100 days was calculated on a basis of a daily feed intake at different rates of body weight using 3 % and 6 %. A daily feed intake at a rate of 3 % of body weight is much less than normally found in intensive trout farming. Here a feed intake at a rate of 5 % of body weight, calculated on fresh fish basis, is close to normal, but even one of 9 % of body weight might be practiced at optimal temperatures, oxygen and water condition.

It is not possible to decide, which assumption on the rate of daily feed intake is appropriate. Quantitative data on the stomach content of bluefin tuna, but also on other tuna species are nearly not existing in literature. The author has found so far only one quantitative information on the feeding volume of skipjack by Waldron (13) who is citing Hotta and Ogawa (1955). The authors give the amount of food consumed in terms of grams of food per kg of body weight. The greatest weight of anyone organism was 81.5 g per kg body weight, with other values ranging down to a few 1/10 of a gram or to 0. Interviews with German tuna fishermen have shown that surprisingly and normally stomachs of bluefin tuna were only slightly filled with rather decomposed prey-fish specimen. Only few fishermen stated that inopened stomachs at most 6-10 kg of fodder fish were recollected, which had been thrown over board for chumming the fish during the catching procedure. This would correspond to a maximum feed intake of 4 %, considering an average weight of 250 kg at the end of the German fishing period. Such observations are, felt however, not to be very conclusive for the normal feeding behaviour of the rest of the population. In this hook and line fishery the tuna were kept together by the angling fleet some times over many days. It seems, as if these tuna were trained to prey at the angling fleet. It was rather normal that 80 angling cutters, each feeding 20-40 baskets of prey-fish per day, kept a large school of bluefin tuna together over periods extending to 10 and even more days.

In Table 6 the feed fish consumption by bluefin tuna under various assumptions during their stay in the North Sea, respectively in the northeast Atlantic, has been estimated.

When looking to the various estimates, the author is inclined to believe that the following 2 estimates come closest to reality: Estimate No. 1 was made under the assumption of a total fish population size, based on a fishing mortality of 10 %, of a K increase = 0.3 and a feed conversion rate = 9; estimate No. 2 of a total fish population size based on a fishing mortality of 10 % and of a daily feed intake for 100 days at a rate of 3 % of body weight. So during the period from 1951-1972 the greatest feed fish consumption of bluefin tuna was achieved in 1952 and was between some 300 000 tons and 425 000 metric tons (Table 6). Most of these prey-fish will have been taken in ICES statistical area IV a, where some 56.8 % of the preying took place.

In the Central North Sea it was the experience of the German hook and line fishermen that mackerel is the favourate bait fish, followed by herring, but also other types of fish such as whiting and haddock were used for chumming.

Hamre in a personal communication reported to the author that in his oppinion the tuna seems to feed on what is available of food species in the area concerned. In area II a he found that the tuna food consisted to at least 90 % of Atlantoscandian herring. Occasionally squid and cod-fishes were found in their stomachs, but never mackerel. Also in the most important fishing area on the west coast (the area west of Bergen) mackerel constituted a minor part of the stomach content. There the tuna feed mostly on herring (0-group) and the small sand eel, the latter was dominant in the early 60-s. However, in the area south of Bergen mackerel has been more frequently found in tunas than from catches taken further north. But also here the tunas have to a large extent fed on other species.

The share of mackerel on the prey-fish consumption of tuna may have been largest in the Central North Sea. Most of the prey-fish taken by the bluefin tuna during its stay in the north-east Atlantic during the time of its great abundance up to 1962 consisted very likely of herring, perhaps to more than 75 %. It is also likely that not more than abount 25 % of

Tab.6 Estimate of feed fish consumption by bluefin tuna under various assumptions during stay in the North Sea

	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Total landings in 1 000 tons	6.8	14.1	9.0	11.1	12.7	5.1	6.9	3.6	4.3	3.7	7.2	8.6	0.2	1.6	2.5	1.0	1.9	0.9	0.9	0.4	0.6	0.1
Total number of bluefin tuna landed calculated on the basis of a standard weight of 200 kg each in 1 000 fish	34.0	71.0	45.0	55.5	63.5	25.5	34.5	18.0	21.5	18.5	36.0	43.0	–	–	–	–	–	–	–	–	–	–
of 300 kg each	-	-	-	-	-	-	-	-	-	-	-	-	0.7	5.3	8.3	3.3	6.3	3.0	3.0	1.3	2.0	0.3
Total population size in number of fish of 200 kg resp. 300 kg each, calculated on the basis of a fishing mortality of 10% in 1 000 fish	340.0	710.0	450.0	555.0	635.0	255.0	345.0	180.0	215.0	185.0	360.0	430.0	7.0	53.0	83.0	33.0	63.0	30.0	30.0	13.0	20.0	3.0
of 20% in 1 000 fish	170.0	355.0	225.0	277.5	317.5	127.5	172.5	90.0	107.5	92.5	180.0	215.0	3.5	26.5	41.5	16.5	31.5	15.0	15.0	6.5	10.0	1.5
of 33.3 % in 1 000 fish	113.3	237.0	150.0	185.0	212.0	85.0	115.0	60.0	71.8	61.7	120.0	143.0	2.3	17.7	27.7	11.0	21.0	10.0	10.0	4.3	6.7	1.0
Feed fish consumption of total fish population calculated on the basis of a fishing mortality of 10% and of a K-increase of 0.2 and a feed conversion rate of 6 in 1 000 tons	69.5	145.0	93.5	113.0	129.0	52.0	70.5	36.8	43.9	37.8	74.5	87,5	2,0	15.3	23.4	9.4	17.9	8.5	8.5	3.7	5.6	0.8
... and a K-increase of 0.3and a feed conversion rate of 9 in 1 000 tons	140.0	294.0	186.0	229.0	262.0	105.0	143.0	74.5	89.0	76.5	149.0	177.0	4.1	31.0	48.5	19.3	36.8	17.5	17.5	7.6	11.7	1.7
Feed fish consumption of total fish population calculated on the basis of a fishing mortality of 20% and of a K-increase of 0.2 and a feed conversion rate of 6 in 1 000 tons	34.7	72.5	46.7	56.5	64.5	26.0	35.2	18.4	21.9	18.9	37.2	43.7	1.0	7.6	11.7	4.7	8.9	4.2	4.2	1.8	2.8	0.4
.... and of a K-increase of 0.3 and a feed conversion rate of 9 in 1 000 tons	70.0	147.0	93.0	114.5	131.0	52.5	71.5	37.2	44.5	38.2	74.5	88.5	2.0	1.5	24.2	9.6	18.4	8.7	8.7	3.8	5.8	0.8

Concl.

	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Feed fish consumption of total fish population calculated on the basis of a fishing mortality of 10% and on the basis of a daily feed intake for 100 days of a rate of																						
3 % of body weight in 1 000 tons	208.0	425.0	270.0	332.0	380.0	153.0	207.0	108.0	128.0	111.0	216.0	258.0	6.3	47.6	74.6	29.7	56.5	27.0	27.0	11.7	18.0	2.7
6 % of body weight in 1 000 tons	416.0	850.0	540.0	664.0	760.0	306.0	414.0	216.0	256.0	222.0	432.0	516.0	12.6	95.2	149.2	59.4	113.0	54.0	54.0	23.4	36.0	5.4
Feed fish consumption of total fish population calculated on the basis of a fishing mortality of 20% and on the basis of a daily feed intake for 100 days at a rate of																						
3 % of body weight in 1 000 tons	104.0	212.5	135.0	166.0	190.0	76.5	103.5	54.0	55.5	57.0	108.0	129.0	3.1	23.8	37.3	14.8	28.2	13.5	13.5	5.8	9.0	1.3
6 % of body weight in 1 000 tons	208.0	425.0	270.0	332.0	380.0	153.0	207.0	108.0	111.0	114.0	216.0	258.0	6.3	47.6	74.6	29.7	56.5	27.0	27.0	11.7	18.0	2.7

total food consumption can have consisted of mackerel, since only a part (some 40-50 %) of the tuna population migrated into the Central North Sea, and since this part fed in this area for about half the season only. After 1962 the percentage of mackerel may have been even considerably lower due to the disappearance of the tuna stock from the Central North Sea.

4. Summary

This paper describes the development of the bluefin tuna fishery in the northeast Atlantic in ICES statistical areas II a, III a, IV a and IV b from 1951-1972. The relationship between the bluefin tuna occurrences on the Norwegian coast and in the Central North Sea is demonstrated by comparing the size composition of the tuna in three different areas on a weekly basis. From these data the migration route of the bluefin tuna during their stay in this area is deduced. The absence of bluefin tuna in the Central North Sea since 1963 is related to the lack of recruit year classes on the Norwegian fishing grounds off the Norwegian coast, which resulted in that since 1963 substantially only one single year class, i.e. the year class 1952, was represented on the west Norwegian coast and remained there throughout the fishing season.

In the period prior to 1963 there were always at least two groups of fish of different age, from which the older one migrated after a few weeks' stay on the north Norwegian coast into the Central North Sea. The disappearance of bluefin tuna in the Central North Sea is because of these circumstances and not because of overfishing on the fishing grounds.

The feed fish consumption by bluefin tuna during their stay in the North Sea has been calculated under various assumptions. It is believed that the prey-fish consumption by bluefin tuna might have been between the following two estimates: Estimate

number 1 was based on the assumption of a total fish population calculated on the basis of a fishing mortality of 10 % and of a K increase of 0.3 and a feed conversion rate of 9. Estimate number 2 was also made under the assumption of a total fish population calculated on the basis of a fishing mortality of 10 %, but then on the basis of a daily feed intake for 100 days at a rate of 3 % of body weight. Feed fish consumption was greatest in 1952 and likely between 300 000 tons and 425 000 metric tons. Up to 1962 more than 75 % of the food fish consumption were likely herring and less than 25 % mackerel. After 1962 the percentage of mackerel may have been even much lower.

5. References

1. Aloncle, H., Hamre, J., Rodriguez-Roda, J. and Tiews, K.:
Fifth report of the Bluefin Tuna Working Group. Observations on the size composition of bluefin tuna catches from 1970 to 1972. ICES, Cooperative Research Reports No. 40: 1-52, 1974

2. Bahr, K.: Untersuchungen über den Roten Thun (Thunnus thynnus, L.) in der Nordsee. Ber. Dtsch. Wiss. Komm. Meeresforsch. 13 (1): 64-78, 1952

3. Hamre, J., Lozano, F., Rodriguez-Roda, J. and Tiews, K.:
Second Report of the Bluefin Tuna Working Group. On the development of the Bluefin Tuna fisheries from 1950 to 1964 and further observations on size composition of Bluefin Tuna catches. Cons. int. Explor. Mer, Stat. News Letters, No. 26: 1-34, 1966

4. Hamre, J., Lozano, F., Rodriguez-Roda, J. and Tiews, K.:
Third Report from the Bluefin Tuna Working Group. Observations on the size composition of Bluefin Tuna catches from 1965-1966. Cons. int. Explor. Mer, Stat. News Letters, No. 38: 1-27, 1968

5. Hamre, J., Maurin, C., Rodriguez-Roda, J. and Tiews, K.: Fourth Report of the Bluefin Tuna Working Group. Observations on the size composition of Bluefin Tuna catches from 1967-1969. Cons. int. Explor. Mer, Coop. Res. Rep., Ser.A, No. 23: 1-49, 1971

6. Hamre, J. and Tiews, K.: Report from the Bluefin Tuna Working Group. On the size composition of Bluefin Tuna catches from 1956-1962. Cons. int. Explor. Mer, Stat. News Letters, No. 20: 1-43, 1964

7. Koops, H., Tiews, K., Tiews, J. and Gropp, J.: Stärke- und Fettverwertung netzkäfiggehaltener Regenbogenforellen (_Salmo gairdneri_). Aquaculture 4 (3): 277-286, 1974

8. Lühmann, M.: Die deutsche Thunfischerei und ihre Fänge in den Jahren 1956-1958. Arch. Fisch.Wiss. 10 (1/2): 68-99,1959

9. Thiel, H.: Thunfisch und Thunfischfang. Der Fischmarkt, Neue Folge, 6 (1): 4-9,1938

10. Tiews, K.: Biologische Untersuchungen am Roten Thunfisch (_Thunnus thynnus_ Linnaeus) in der Nordsee. Ber. Dtsch. Wiss. Komm. Meeresforsch. 14 (3): 192-220, 1957

11. Tiews, K.: Synopsis of biological data on bluefin tuna _Thunnus thynnus_ (Linnaeus) 1758 (Atlantic and Mediterranean). Proceedings of the World Scientific Meeting on the biology of tunas and related species. FAO Fish. Rep. 6 (2): 422-481, 1963

12. Tiews, K.: Der Thunbestand (_Thunnus thynnus_ L.) in der Nordsee, seine Wanderungen, seine transatlantischen Beziehungen und seine Nutzung durch die deutsche Fischerei. Arch. FischWiss. 14 (3): 105-148, 1964

13. Waldron,K.D.: Synopsis of biological data on Skipjack _Katsuwonus pelamis_ (Linnaeus) 1758 (Pacific Ocean). FAO Fisheries Reports 6 (2): 695-748, 1963