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Feeding behaviour and formation of fish concentrations in the chub
mackerel (Scomber colias) in the Northwest African fishing grounds

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By comparing the Northwest African fishing grounds with the traditional ones in the North Atlantic one can state several particularities characteristic of subtropical and tropical regions. The hydrological conditions don't change abruptly during the annual course of seasons, the illumination in summer and winter is not as different as in the north and during the whole year a good, though different food supply is available for the fish.

On the other hand as in other fishes biological processes like growth, maturation, and reproduction are regulated and timed.

In pelagic fishes horse mackerel, chub mackerel, sardinella and pilchard, caught in african waters, the occurrence and formation of their concentrations is influenced by a complex of biotic and abiotic environment factors determined by the actual hydrometeorological system in the upwelling areas. In this report some observations about the feeding type of the chub mackerel (Scomber colias) are reported and possible relations to the concentration effect discussed. Among the named species chub mackerel shows a typical behaviour and we dispose the most extensive material of it.

Material

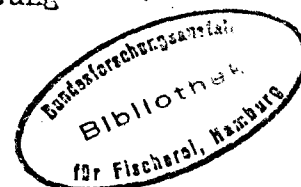
The observations were carried out from 1970 - 1973 on board of research and factory ships in the area of 24 - 19°N and 14 - 11°W. All samples have been taken in a depth range of 40 - 190 m on the slope and came from the centre of the fishing grounds in order to trace periodic and rhythmic processes. In total 1500 fishes and stomachs have been analysed. The estimation of the stomach filling was done according to a four grade scale and additionally stomachs were weighed.

Food composition

The food includes a wide range of organisms. The food was composed by following main groups:

Euphausiides	}	60-65 %	Sagitta	}	0-15%
Copepodes			Amphioxus		
Mysides	}	20-25%	Worus		
Phytoplanton			}		
	Decapods, shrimp				
	Fishes				
			Cephalopodes		
			Ostracodes		

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In fishes with a length of 24 - 30 cm copepods, euphausiids and phytoplankton prevailed, in a range of 30 - 37 cm all organisms occurred and older fishes frequently fed on larger objects such as tunicates, shrimp, fishes, cuttlefish and benthic animals. Distinct seasonal differences in the food composition could not be observed. In autumn the food was composed more homogenous, while in spring copepods were less abundant.

Filling of the stomach-intestine tract

Unlike to the other fishes chub mackerel fed very strong in all seasons of the year. In regard of the feeding rhythm it corresponded to the rhythm of the horse mackerels and differed from the sardinellas (Fig. 1).

The following table shows the average quantity of the stomach contents in 34 - 36 cm long fishes:

<u>Degree of the filling</u>	1	2	3	4
Average weight	2,5	4,0	6,0	12,8

The mean filling of the stomach in the feeding periods of the day found to be 7 - 9 g of wet food in mackerels of a length of 34-36cm. However, on days with good plankton supply mackerels took up 25 g up to complete filling of the body cavity by the filled stomach and intestine. Assuming 2 - 3 feeding periods per day one can compute a daily food ration of nearly 25 g per day/fish, i. e. about 10 % of the body weight. In strong feeding periods fishes took up 40 g and more food per day.

Regional differences in feeding:

In fig. 2 can be seen that in three areas good feeding could be determined:

1. 20°20' - 20°50' N (Cape Blanc)
2. 21°20' N
3. 22°00' - 22°15' N

In the region of Cape Blanc could be found the least annual fluctuations in feeding, while feeding got poor in the area of 21 - 21°30' in late autumn and winter.

Seasonal differences in feeding

The differences in total feeding activity in various months are small. In fig. 3 can be discerned the tendency. The highest feeding values occur in July and August, in September feeding is still good, while since October a decreasing tendency is evident. Strong feeding is characteristic of December/January and during the main spawning

time of the fishes in February feeding changes slightly.

Short-time fluctuations in feeding

In order to trace the course of feeding samples were taken for several weeks on a ship being for a longer time in the centre of the main fish concentrations. Samples of 50 - 100 stomachs were analyzed day and night whenever a haul had been done. The position of the ship was 20°50' - 21°20' N. In fig. 4 is shown a typical curve of the feeding activity for autumn months. In particular in the daylight curve can be seen that the mackerels didn't feed continuously strong, but strong feeding periods alternated undulating with poorer ones, i.e. feeding increases continuously and slopes in the same way. The duration of a good feeding period is about 4 - 5 days. The same tendency follows from the night curve, though less obvious. To what extent these "oscillations" in feeding are connected with the variations of upwelling and their effects on plancton dynamics is not discussed in this paper. Fig. 5 shows the situation in other seasons.

Feeding and moon phase

In general feeding activity in daylight was stronger than during the night. Nevertheless there is a certain relation to the moon phase possibly by affecting the diurnal vertical movements. In fig. 6a) is shown the filling of the stomach in different moon phases. The fig. outlines that the highest values are related mainly to the full moon and waxing moon periods. Fig. 6b) summarizes up the particularities of feeding in different moon phases. Additionally in fig. 7 is given the stomach filling for autumn time compiling feeding of the adequate days of each moon phase where feeding maxima are found more or less in full moon and waxing moon. Other relations follow in the next paragraphs.

Feeding and catches

In fig. 4 feeding activity is compared with the catch per day of the ship. Both in summer and autumn from the daytime curves results a coincidence between feeding and catch results. This is less distinctly marked in the night.

Diurnal feeding activity

To analyze the diurnal course of feeding in fig. 6a) was given the mean stomach filling during the 24 hours of the day for the summer/autumn time. According to that during the course of the day 2, rarely 3 feeding periods seem to appear. The main feeding time was at all times in the afternoon up to the first hours after dusk, the second by 10 - 12 o'clock and sometimes a third shortly before dawn. Thus a picture of the diurnal feeding activity results as follows: In the morning after sunrise towards 8 - 10 o'clock low feeding, 10 - 14⁰⁰ low or increasing feeding, 15 - 18⁰⁰ permanent or heavy rise of feeding, fairly well filled stomachs still up to 22⁰⁰ occa-

sionally increasing feeding. In late autumn mackerels started feeding already towards 12 - 14⁰⁰. In summer the fishes fed almost during the whole daytime, after sunset feeding decreased continuously reaching the minimum at 5 - 8⁰⁰.

Inspecting diurnal differences in various moon phases showed small obvious features. In full moon periods strong feeding activity can be seen before and after sunset and decreasing activity up to midnight remaining small up to the morning. In new moon and waxing moon periods fishes are longer active in the night, reaching the minimum only towards 4⁰⁰.

Diurnal feeding cycle and catches

Unfortunately the curves of the catches in different times of the day are not sufficiently expressiv depending on the used fishing method. (Fig. 8)

Summer : The curves of the total catch/ per time and feeding correspond

Autumn : The feeding and catch curves are quite synchronous except the night situations in full moon and waning moon, where an opposite tendency is evident. In these periods the catch maximum per day is reached before the feeding maximum.

This coincidence between catch and feeding especially in daytime illustrates the before named relationship between feeding and catches.

Trawling time during the day and feeding

From the curves 9 and 10 follows a reverse relation of trawling time to the feeding activity. This is most obvious in full moon and waxing moon, less clear in the other phases. According to this there are the following characteristics in the used trawling time during the day: Long trawling times in the morning up to noon, permanent decrease up to the sunset (except new moon), increase continuously from midnight up to the morning. This gives us some instructions about the concentration rate of the shoals. Additionally some notices about the number of hauls done : after sunrise good many hauls with small catches were done, during the day the number of hauls was small while after sunset a considerable number of hauls (with quite bad success) was necessary and in the second half of the night few lucrative hauls succeeded.

Vertical movements

Fig. 9 shows the diurnal vertical movements of the mackerels. Between 11 - 14⁰⁰ the fishes reach their maximum depth, in the afternoon they start gradually rise up and during dusk they rise up quickly 20-40 m into the surface. During the night depth level

drops slowly up to the morning, in the dawn the fishes abruptly descend, at first into the lower part of the midwater, then down to the bottom. The migration amplitude in late autumn and winter turned out to be longer. In new moon and waxing moon the evening rise is expressed best. In new moon periods in the night towards 20 - 22⁰⁰ the fishes come up closer to the surface than in other periods. From all named items can be designed a working scheme for the diurnal activity of the mackerels.

Working scheme of the factors feeding-shoaling in diurnal cycle

From the observations follows that feeding takes part in the formation of mackerel concentrations. However feeding is only one factor affecting the character of the concentrations, acting together with other conditions. Strong feeding is not always connected with good catches, but in daytime it decisively influences the fishing results.

This is the summarized activity pattern:

During sunrise chub mackerel shoals descend quickly from the upper parts of midwater into the deeper ones. Up to 10⁰⁰ they gradually go down to the bottom and rest on or above the bottom between 10-14⁰⁰. When descending fishes appear in small shoals or loose concentrated and a lot of hauls is required to work successfully, while trawling time and search is high. Before noon fishes feed poorly. In the afternoon they begin to migrate either on the bottom onshore (shallower) or to lift over the bottom and go up slowly. In this time the mackerels feed over the bottom. Simultaneously concentrations obviously get denser, shoals enlarge and the catches increase, while trawling time and number of the hauls decreases. At this time fishes are at the edge of the slope. From 16 - 18⁰⁰ feeding and catches per hour rise up considerably. During sunset fishes move up into the midwater in a short time and remain still concentrated after this. However the catches drop during the rise. Up to 21⁰⁰ mackerels continue feeding and reach the surface layers towards 22 - 24⁰⁰. Up to 5⁰⁰ feeding decreases permanently. At the same time fishes slowly descend in the midwater. Thus up to 24⁰⁰ quite successful hauls can be taken however one can notice beginning dispersion of the shoals. Trawling time is relatively small. Since midnight trawling time raises up to the morning and the number of the hauls drops possibly by loose concentrations of the shoals, especially towards 2 - 4⁰⁰. Shortly before sunrise can be seen a slight "new"-concentration with better catches after dawn.

The most important factors influencing this scheme are such as wind, currents and cloudiness.

Mean filling of stomach

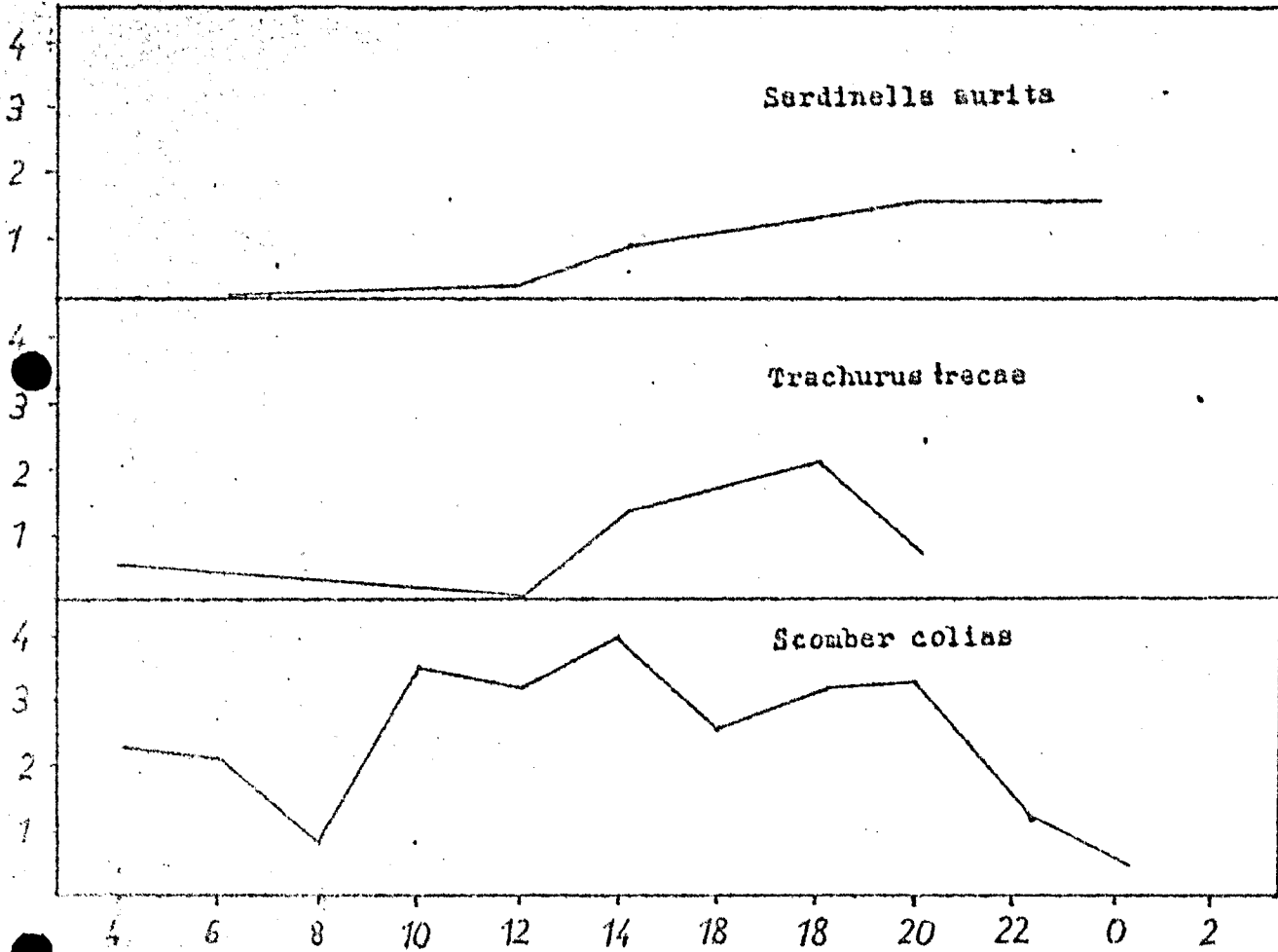


Fig. 1 Feeding type in several pelagic fishes

Hours

Mean filling of stomach

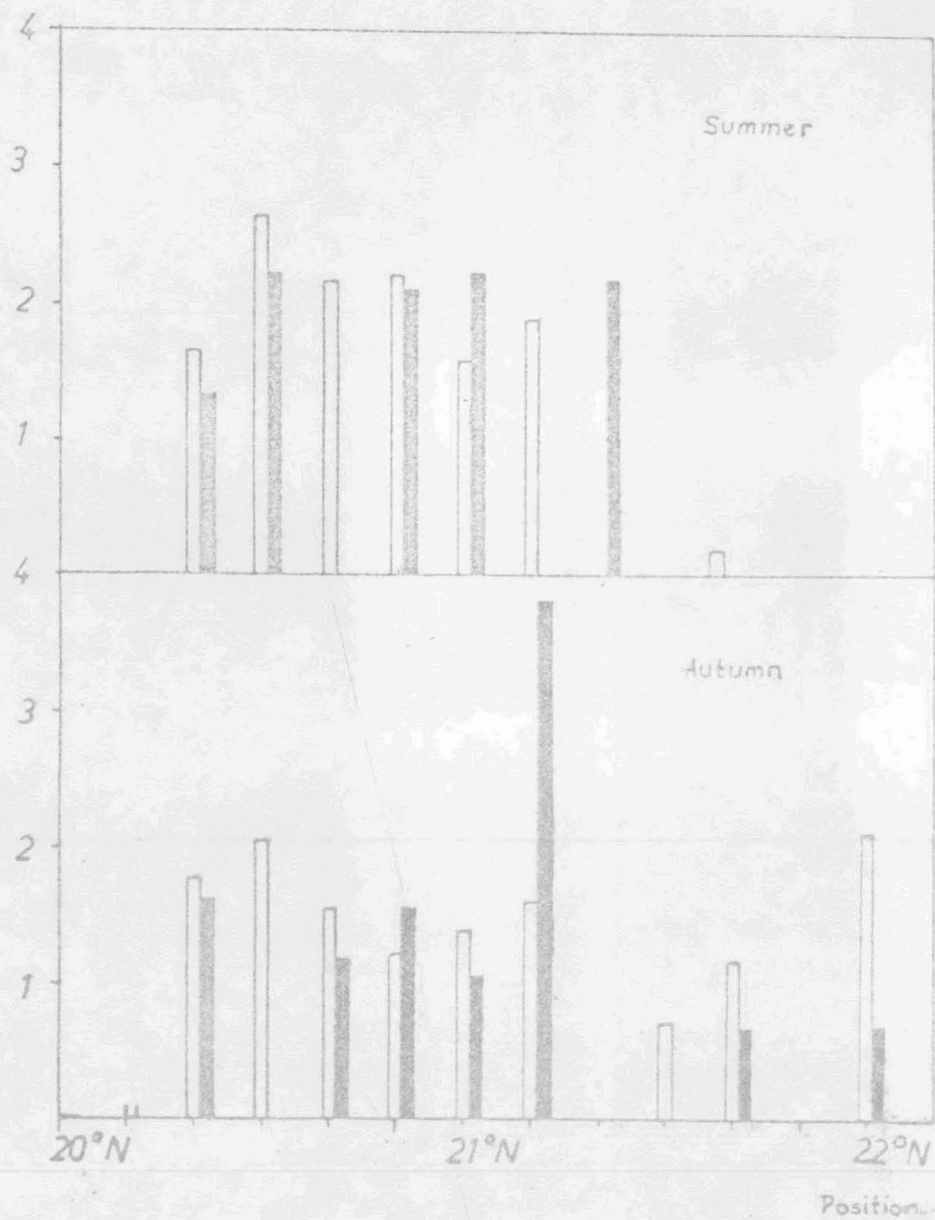


Fig. 2

Feeding in different regions

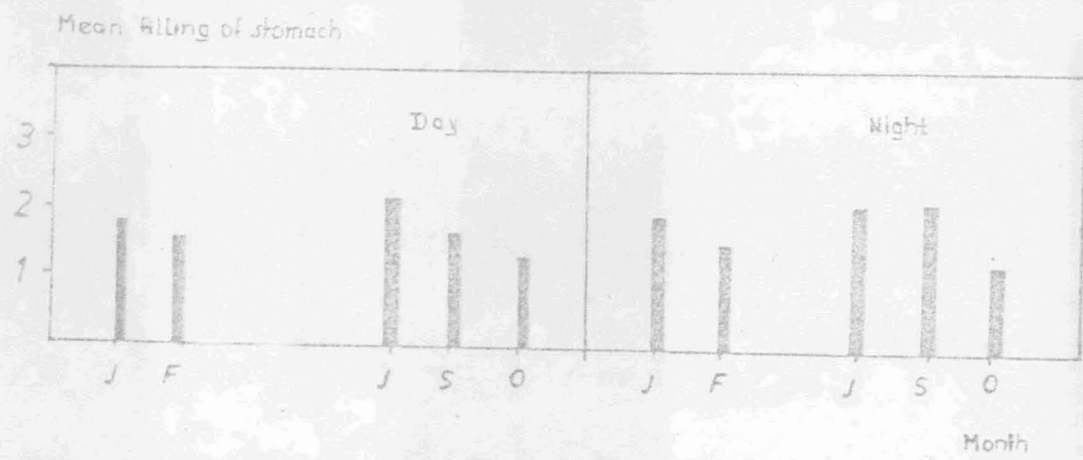


Fig. 3 Feeding in different months

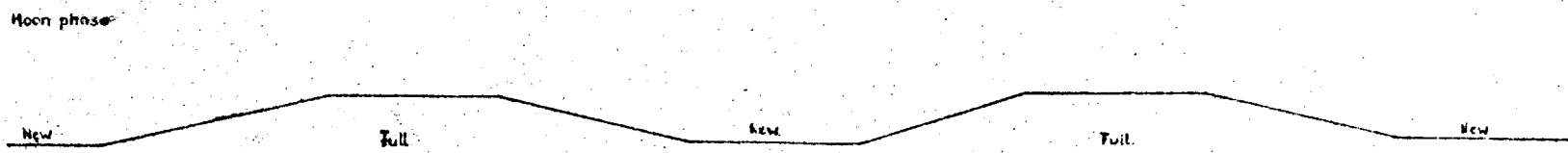
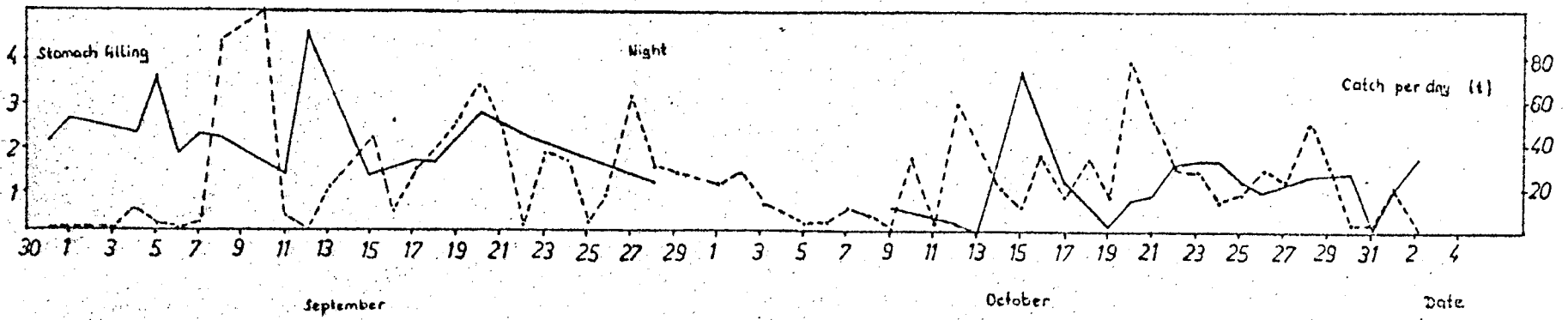
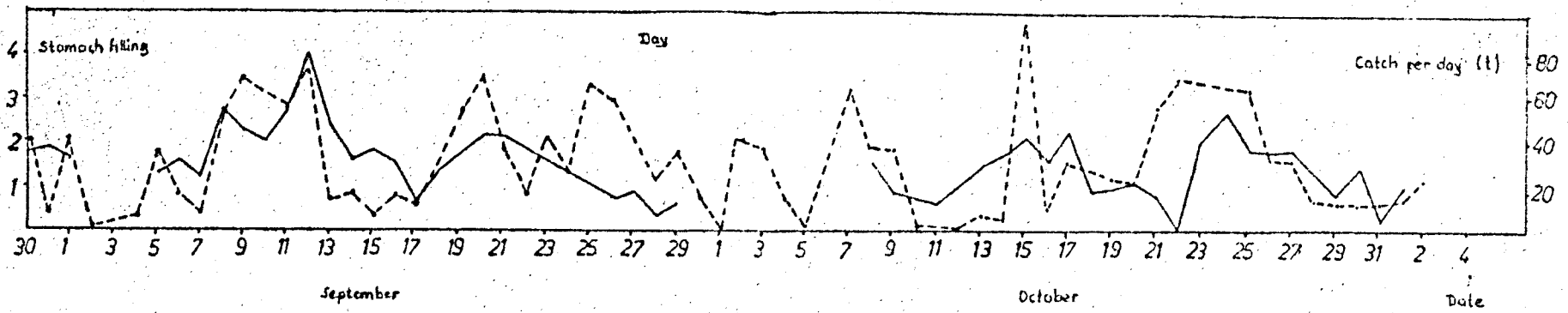


Fig. 4 Feeding rhythm and catch per day (autumn) — Stomach — — — — Catch per day

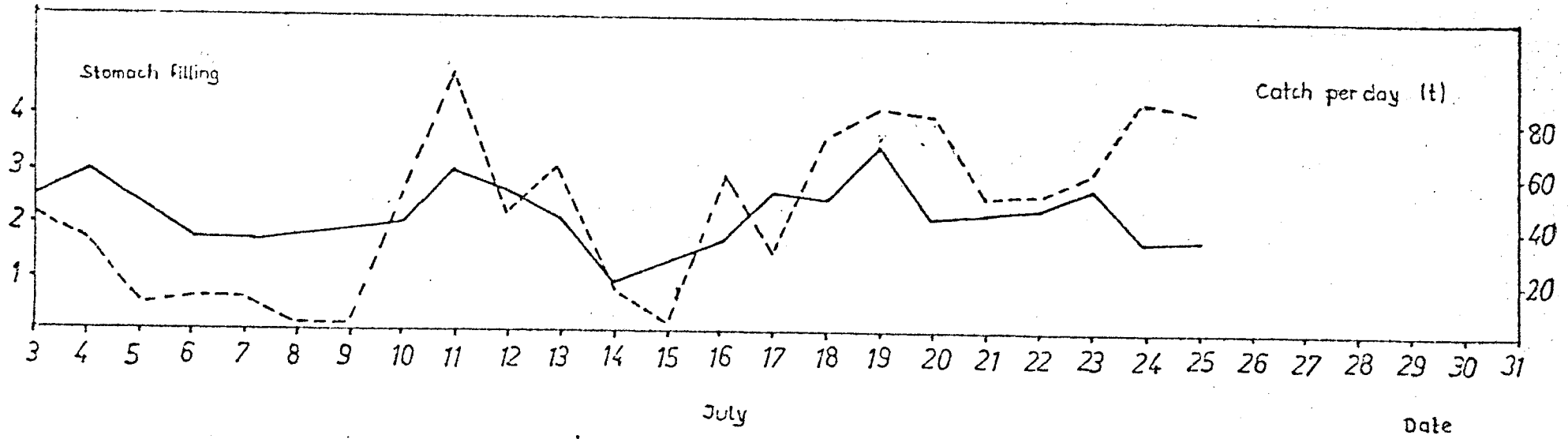


Fig. 5 Feeding rhythm and catch per day (summer)

— stomach

- - - - - catch per day

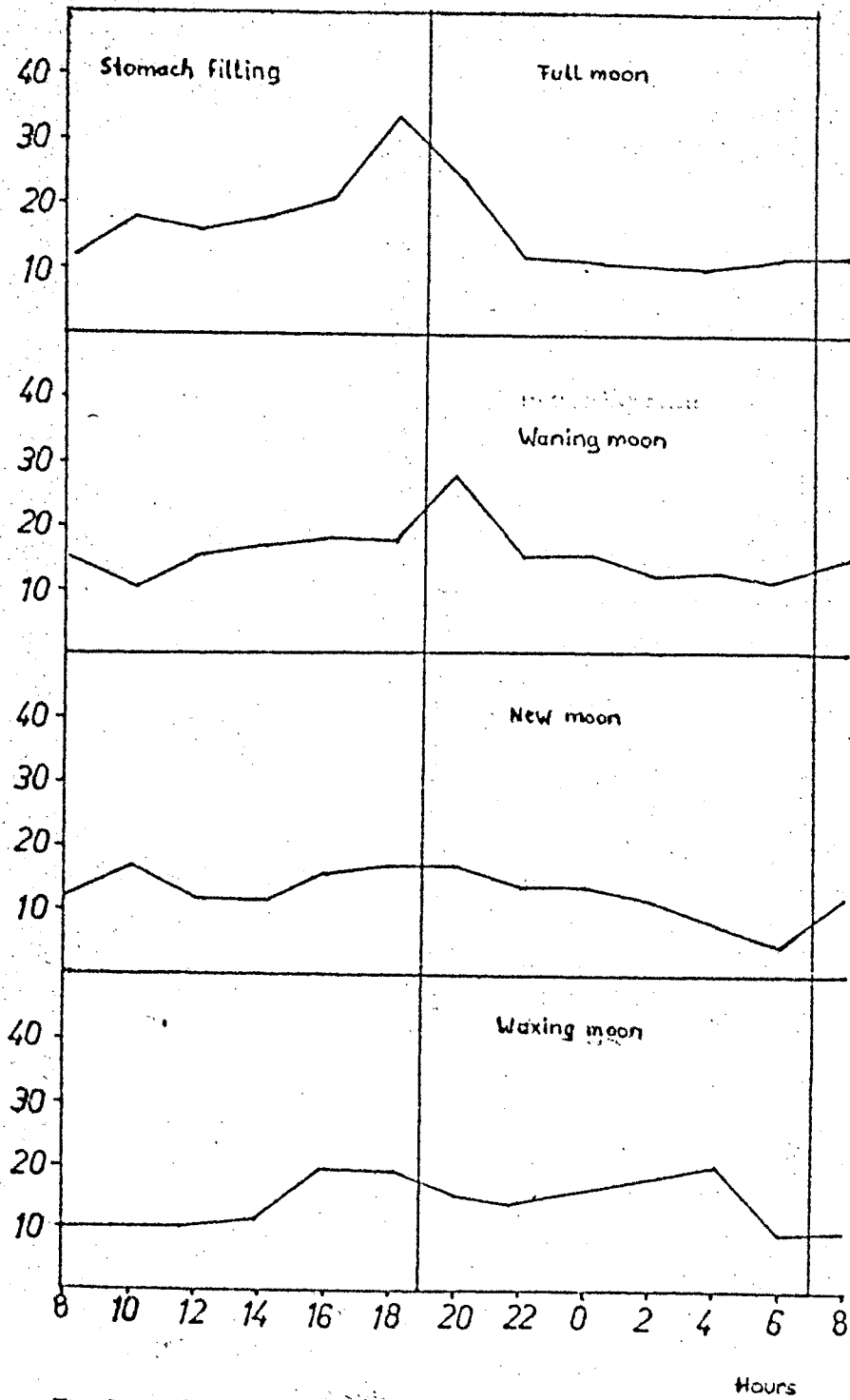


Fig. 6a Feeding in different moon periods (autumn)

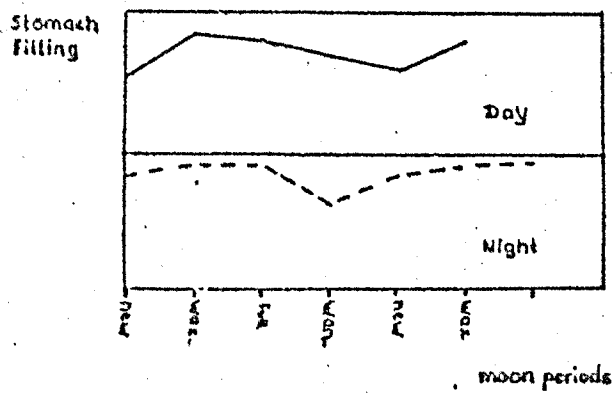


Fig. 6b Average feeding in various month periods

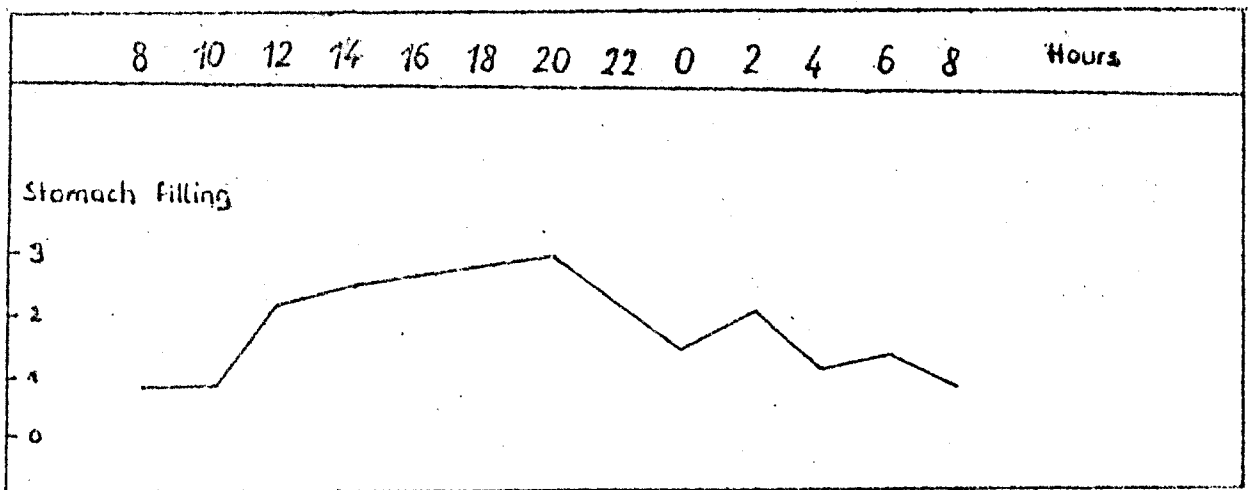


Fig. 6a Diurnal feeding cycle (Summer)

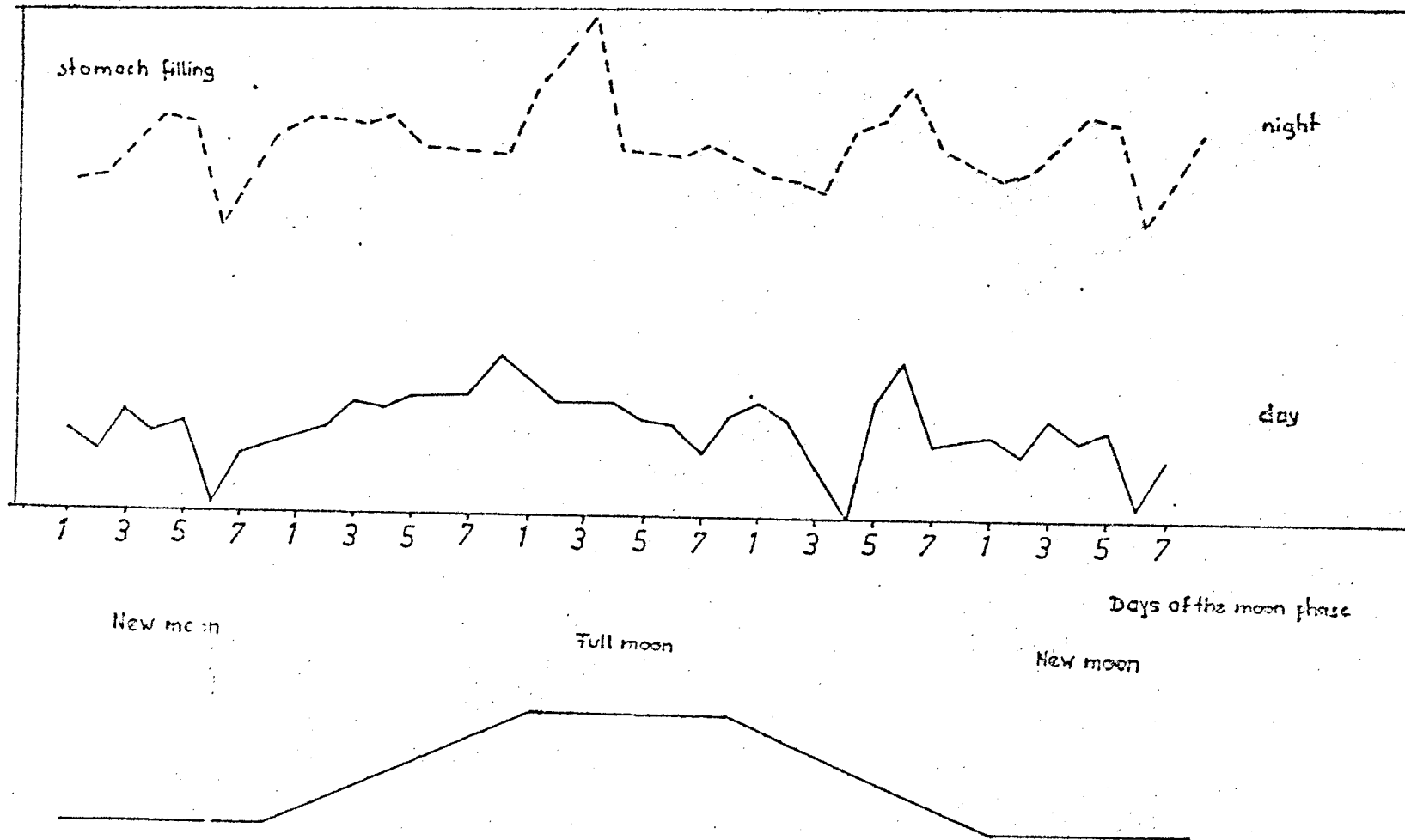


Fig. 7 Feeding during different moon phases

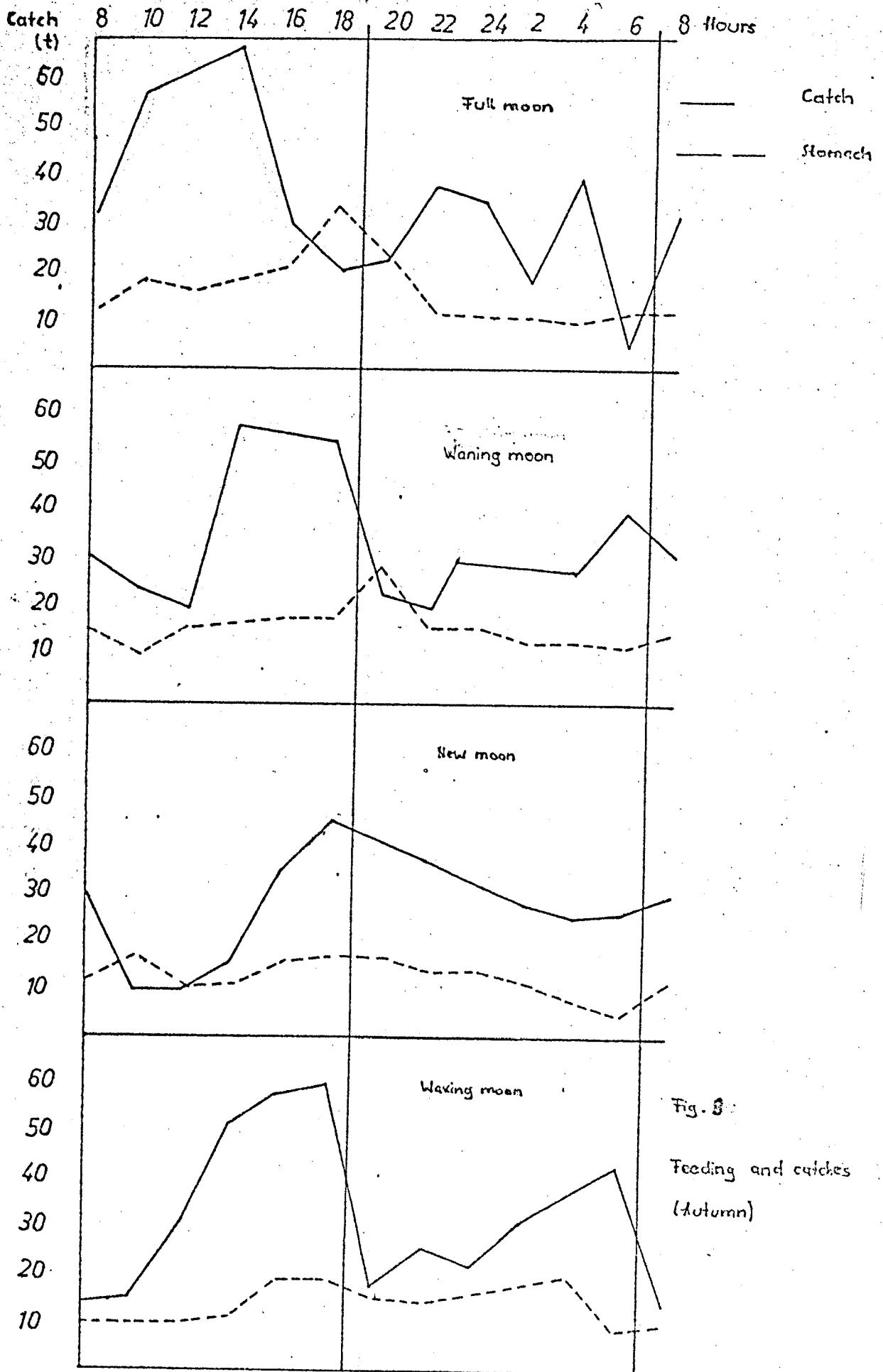


Fig. 3
Feeding and catches
(Autumn)

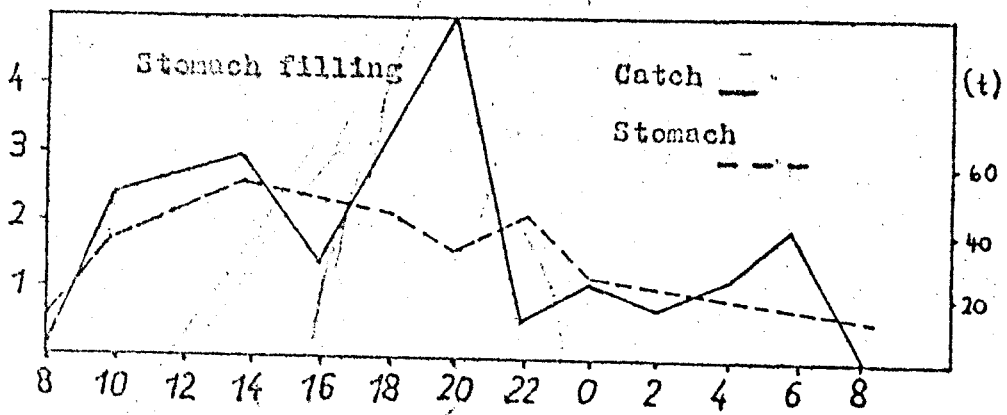


Fig. 8. Feeding and catches (summer)

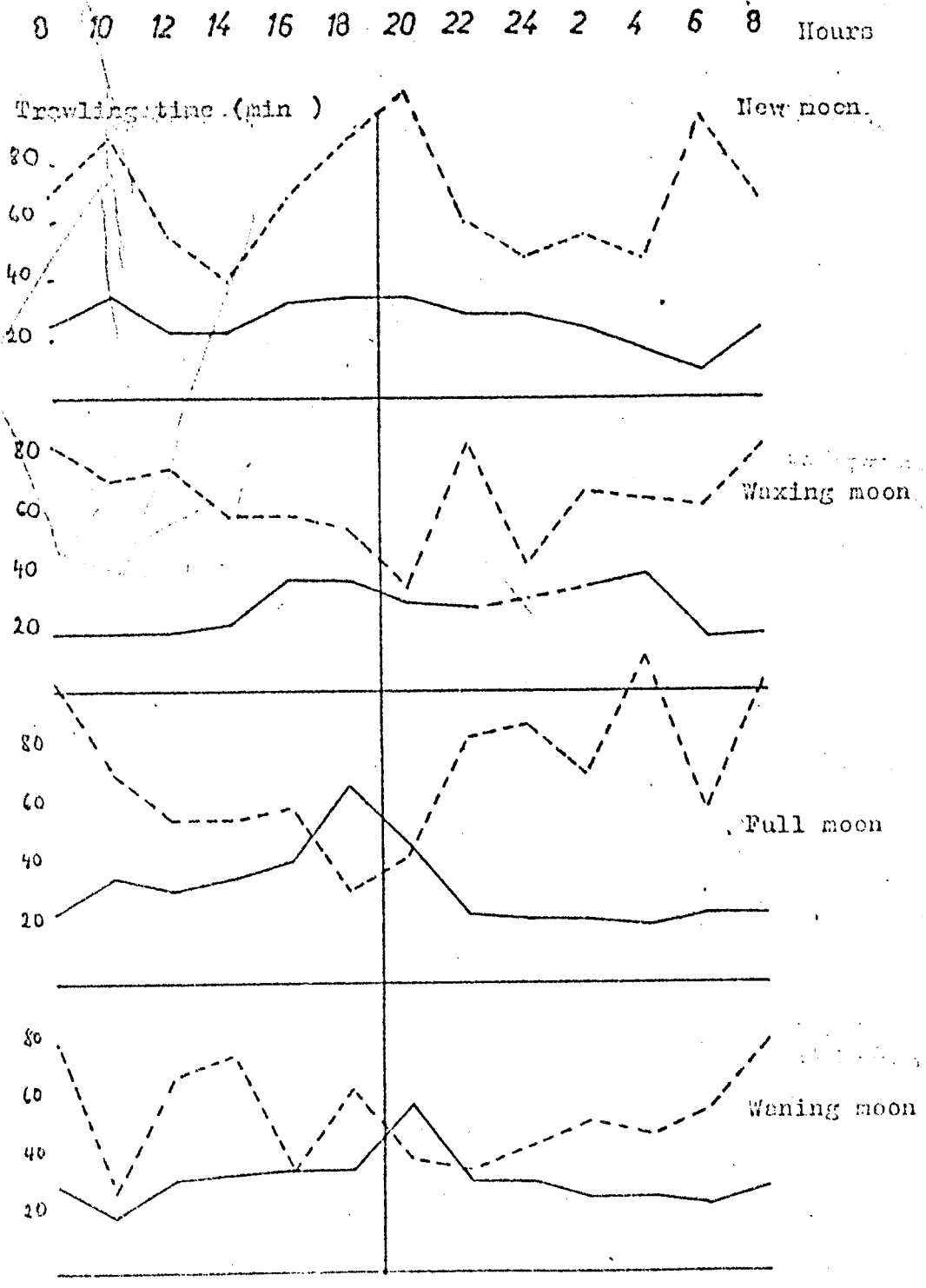


Fig. 9 Feeding and Trawling time

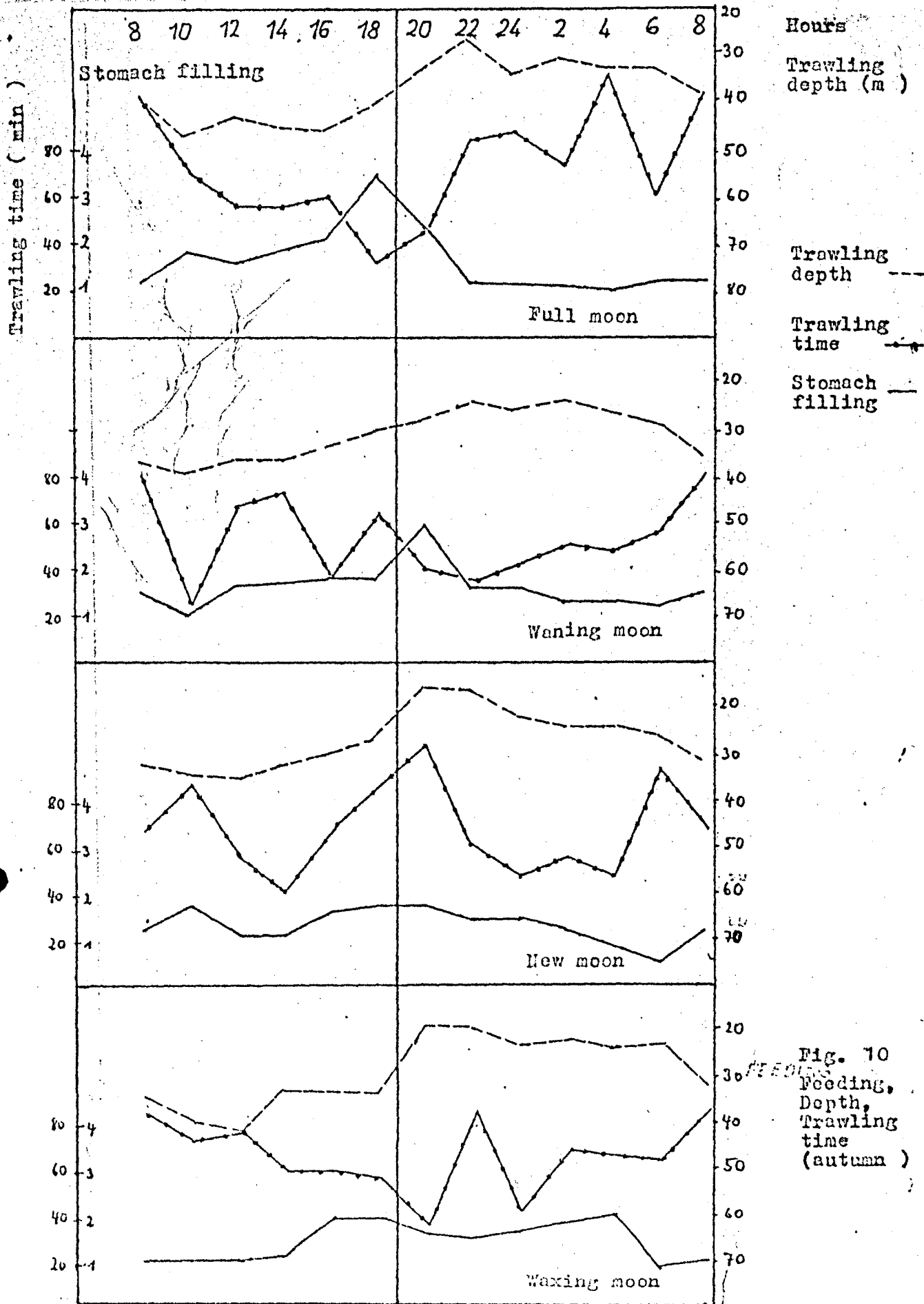


Fig. 10
Feeding,
Depth,
Trawling
time
(autumn)