International Council for
the Exploration of the Sea

C.M.1990/E:31
Ref.G

INFESTATION OF NORTH SEA WHITING (MERLANGIUS MERLANGUS L.) WITH EXTERNALLY VISIBLE PARASITES

by

Thomas Lang
Bundesforschungsanstalt für Fischerei
Aussenstelle Cuxhaven
Bei der Alten Liebe 1
2190 Cuxhaven
Fed. Rep. Germany

ABSTRACT

During 5 research cruises in May/June '88, January and May/June '89, and January and May '90 into the North Sea the occurrence of the parasites **Lernaeocera branchialis**, **Clavella adunca**, **Diclidophora merlangi**, and **Cryptocotyle lingua** in whiting (Merlangius merlangus) was recorded. Out of these, D. merlangi turned out to be the most frequent one, followed by C. adunca, L. branchialis, and C. lingua. In the southern whiting stock, L. branchialis and C. adunca were predominating, whilst D. merlangi was the main parasite of the northern stock. C. lingua was quite evenly distributed amongst fish of the two stocks. In L. branchialis and C. lingua, there was evidence for a positive relationship between total length of fish and prevalence of infestation, which, however, only was found in fish sampled during the spring cruises. In contrast, both the spring and winter data for C. adunca revealed a negative relationship. In D. merlangi sampled in both seasons, a first increase of prevalence with increasing total length was followed by a later decline. Comparing the prevalences found on the successive cruises, there is indication for decreasing prevalences of infestation with L. branchialis and C. adunca, whereas no such consistent trend seems to exist in the other parasites studied.

INTRODUCTION

Although whiting (Merlangius merlangus) is one of the most abundant and economically important fish species in the North

Sea, information on spatial and temporal distribution of its main parasites is sparse, and, if available, allmost restricted to British waters. Exceptions are the studies by MÜLLER (1982) and by PILCHER et al. (1989), who recorded the infestation of whiting with L. branchialis, C. adunca, and D. merlangi for 1977-1981 and 1985-1986, respectively.
To complete our knowledge on regional and seasonal trends of parasitic infestation, the examination of whiting for at least externally visible parasites has been included in the routine fish disease monitoring programme of the Federal Research Board for Fishery covering the whole North Sea area.
The parasites under examination are the crustaceans **Lernaeocera branchialis** (Copepoda: Pennellidae) and **Clavella adunca** (Copepoda: Lernaeopodidae), and the trematodes **Diclidophora merlangi** (Monogenea: Polyopisthocotylea) and **Cryptocotyle lingua** (Digenea: Heterophyidae).

The objective of this paper is to provide some current data on the occurrence of the four North Sea whiting parasites studied in different seasons (spring and winter) within the time span 1988-1990. Information is given on regional and seasonal aspects of infestation, and, additionally, results on the relationship between length of fish and prevalence of infestation are presented.
The term "externally visible parasites" in the title of this paper was chosen, since apart from the ectoparasites L. branchialis, C. adunca, and D. merlangi also the endoparasitic, but externally visible trematode C. lingua has been studied. It should be noted, however, that L. branchialis is not generally accepted as being an ectoparasite, due to the fact that large parts of its body are anchored within the tissue of its host.

Out of the 4 parasites, Lernaeocera branchialis is the best documented one, probably due to its impressive appearance. In the North Sea, adult stages of L. branchialis (exclusively females) mainly infest gadids, where they can easily be found attached to the wall of the gill chamber. Fully developed parasites are blood-red, typically S-shaped, and reach a maximum size of approximately 2 cm.
The main host of the juvenile stages in the North Sea is the flounder (Plathichthys flesus), which is restricted to the shallow coastal areas.
More detailed information on anatomy, taxonomy, biology, and effects of L. branchialis on its hosts can be found in SCHUURMANS STEKHOVEN (1936), SCHUURMANS STEKHOVEN and PUNT (1937), SPROSTON and HARTLEY (1941), MANN (1952), KABATA (1961), SUNDNES (1971), SHOTTER (1973 a,b), Van den BROEK (1978, 1979b), HISLOP and SHANKS (1981), KABATA (1981), MÜLLER (1982), KABATA (1984), POTTER et al. (1988), PILCHER et al. (1989), and ANSTENSRUD (1989, 1990).

The life-cycle of the copepod Clavella adunca only includes one host, which in the North Sea also can be represented by different

members of the gadids. In infested fish, C. adunca can be seen in the gill chamber, where it is usually attached to the gill filaments or rakers. Additionally, the buccal cavity and the tissue around the anus or the fins can be affected (the latter mainly in cod, Gadus morhua). The parasite is white-yellow coloured and has a size of 5-7 mm, depending on its stage of development. As in case of L. branchialis, the conspicuous parasites are females, the males spend their lives as pigmy-males attached to their mates.
For more comprehensive information see POULSEN (1939), KABATA (1963), SHOTTER (1971), KABATA (1984), Van den BROEK (1979b), MÜLLER (1982), POTTER et al. (1988), and PILCHER et al. (1989).

The monogenean trematode Diclidophora merlangi inhabits the gills of whiting, where it is attached to the gill lamellae mainly of the first gill arch. With increasing intensity of infestation (number of flukes per fish) also the other arches can be affected. Macroscopically, the parasite appears to be coloured brown, roundish or rhombus-like, with a diameter of approximately 5 mm. The transmission of this parasite is direct without the intervention of an intermediate host.
More details on the occurrence, host-specifity , and adhesive attitudes of D. merlangi can be found in LLEWELLYN (1956, 1958), LLEWELLYN and TULLY (1969), SMITH (1969), ARME and HALTON (1972), SHOTTER (1973a), and MÜLLER (1982), and PILCHER et al. (1989).

Cryptocotyle lingua is a digenetic trematode of the northern hemisphere infesting a large variety of fish species. Its life-cycle includes two intermediate hosts (snails and fish) and a definite host, which is represented by various piscivorous sea birds, mainly gulls. In fish, the metacercariae are encysted in the subcutaneous tissue, where they can easily be identified as small ($\leq$1mm) black spots, frequently occurring in large numbers on the entire body surface of the fish infested, predominantly above the lateral line. For more information on the life-cycle and distribution of C. lingua in North Sea waters see STUNKARD (1930), WERDING (1969), SHOTTER (1973a), Van den BROEK (1979a), KOIE (1983), and POTTER et al. (1988).

MATERIAL AND METHODS

During 5 cruises with RV "WALTHER HERWIG", altogether a total of 14994 North Sea whiting were examined for the occurrence of externally visible parasites. The dates of the cruises are listed below.

WH 90	26.05. - 08.06.1988
WH 94	03.01. - 17.01.1989
WH 98	18.05. - 08.06.1989
WH 103	03.01. - 19.01.1990
WH 107	04.05. - 24.05.1990

Whiting were sampled on 14 stations conducting up to 11 one hour hauls/ station with a GOV-bottom trawl with codend. Fig. 1 shows a map with the stations taken during different cruises. Included is the borderline between the two main whiting stocks in the North Sea, which had been introduced by MESSTORFF (1959). In the following, the southern area will be called area A and the northern one area B.
From Tab. 1 the stations used during the different cruises and the number of whiting examined can be seen.
Figures for the number of whiting examined per cruise and per cm total length within areas A and B are given in Tab. 2. Not included is the number for station 9, which does not fit into MESSTORFF's division of the North Sea.

The examination of the whiting for parasites was conducted following the measurement of total length by carefully looking at the skin surface and into the buccal and gill cavity, while spreading the gill arches, which had been cleant before with running sea water. In case of Lernaeocera branchialis, apart from the alive stages also remains of freshly dettached copepods were counted as parasites.

All input and calculations of data have been conducted using a special computer programme designed for disease monitoring purposes, which, at present, only allowes calculations of disease prevalences (including parasitic infestation). For this reason, within this article no information can be provided on intensities of infestation (number of parasites per fish).

RESULTS

Figures 2-5 give the percent prevalences of infestation with the 4 parasites found in all whiting examined at the different stations. The bars in each figure represent from left to right the prevalences found during successive cruises; the spring cruises are symbolized by dark bars, the winter cruises by light bars. The asterisks stand for cruises, during which no sampling of fish took place at the marked stations.
When comparing prevalences of the 4 parasites, the different scales given in the right lower corner of each figure have to be taken into account.

In Figures 6-9 the relationship between the total length of whiting examined and the percent prevalences of infestation is demonstrated for the different parasites studied. In the upper graphs, the data recorded during the spring cruises are depicted, in the lower ones those found on the January cruises. Only data from those areas are shown, which exhibited highest prevalences. For better clarity, the results are not presented stationwhise, but summarized for all whiting sampled within the whole area. Percent prevalences are only depicted for cm-length classes with

N $\geq$ 10 (The number of fish examined per length class can be found in Tab. 2).

1. Lernaeocera branchialis

For L. branchialis the results clearly revealed the highest prevalences in whiting of area A, particularly in the eastern part at stations 1, 3, and 11 (Fig. 2). Whereas at station 11 only the spring-cruises resulted in high prevalences, the values found at stations 1 and 3 during all cruises were consistently elevated compared with the other stations. Maximum infestation rates in spring and winter were both recorded at station 1 in the German Bight with prevalences of 41.3 % (WH90) and 42.9 % (WH94), respectively. In area B (and station 9), only few infested fish could be caught during all of the cruises.
Out of the data shown in the figure, there is no clear indication for periodically occurring seasonal changes of prevalence, although the infestation rates registered in spring seemed to be elevated insignificantly.
Comparing the results of the successive cruises, there seems to be an overall decreasing trend of infestation from May/June '88 until May '90.

In Fig. 6 the relationship between total length of whiting examined and prevalence of infestation with L. branchials is illustrated for area A. The upper graph shows a clear positive relationship between length of fish and prevalence of L. branchialis, which could be demonstrated independently for all three spring-cruises. In contrast to the cruises in '89 (WH98) and '90 (WH 107), during which quite similar results were obtained, the values found in '88 (WH90) were considerably elevated, particularly in whiting between 20 and 30 cm total length. In the course of the winter-cruises (lower graph) no positive relationship was evident. The results of both cruises in January '89 (WH94) and '90 (WH103) revealed a first maximum of infested fish at approx. 19 cm, followed by a decline of prevalence, and a second maximum in fish between 25 and 30 cm total length. In total, the prevalences recorded in January '89 were much higher compared with those of the following year.

2. Clavella adunca

The spatial distribution of C. adunca and the time trends of infestation frequency are shown in Fig. 3. At first glance the graph indicates, that C.adunca did occur more frequently in North Sea whiting and was more widely distributed than L. branchialis. The fish of area A seemed to be more affected than those of area B. Especially north of 57°00'N latitude the prevalences were found to be much lower compared with the region south of 57° 00'N. The maximum spring-prevalence was recorded in May/June '88 (WH90) at station 10 with 81.2 %, and the maximum winter-preva-

lence during the January-cruise '89 (WH94) at station 5 with 76.5 %.
Again, a clear trend for differences in the prevalences between the seasons could not be demonstrated.
Comparable to L. branchialis, also the data for C. adunca seem to show a decreasing trend of infestation with time.

The length-prevalence relationship in whiting of area A infested by C. adunca is shown in Fig. 7. The upper graph, giving the results of the spring-cruises, again clearly indicates a relationship between the length of whiting and the prevalence of infestation. In contrast to L. branchialis, however, this time a negative relationship is evident. The lower graph, illustrating the findings of the winter-cruises, shows a similar trend, although not that clearly. Again, the prevalences in whiting sampled during the May/June cruise '88 (WH90) were much higher than in spring '89 (WH98) or '90 (WH107), reaching values of more than 90 % in whiting < 15 cm. The prevalences of C. adunca in January '89 (WH 94) shown in the lower graph were only elevated within the length range of 18-21 cm compared with the percentages found in January '90 (WH 103).

3. Diclidophora merlangi

The spatial distribution of whiting infested by the gill fluke D. merlangi differed from that found for L. branchialis and C. adunca. Fig. 4 shows highest prevalences of infestation in area B, and there particularly at the stations farthest to the north. The maximum spring-prevalence was recorded at station 8 of cruise WH90 in '88 with a value of 91.7 %, the maximum winter-prevalence was 86.7 % at station 7a of the subsequent cruise WH94 in January '89. In total, D. merlangi was the most frequently found parasite in North Sea whiting.
Consistent seasonal trends of prevalences again are not evident. In contrast to the other parasites, there is no indication for a decreasing trend of infestation during the period of investigation, although also in case of D. merlangi the highest prevalences were mainly found on the first two cruises in May/June '88 and January '89.

To demonstrate the length-prevalence relationship for D. merlangi, the findings in area B are depicted, in which this parasite did occur much more frequently than in area A. As can be seen in Fig. 8, both the spring data and the winter data revealed the same kind of relationship. At first, there seemed to be an increase of prevalences up to a total length of whiting of approx. 24-25 cm, partly resulting in maximum prevalences of more than 90 % during May/June '88 (WH90) and January '89 (WH94). After that, the percentages of infested fish remained on a plateau or even seemed to decline again.

4. Cryptocotyle lingua

Out of the 4 externally visible parasites studied, C. lingua was the less frequently occurring one. Prevalences measured at the different stations of the 5 cruises are shown in Fig. 5. The differences between prevalences in areas A and B were only low, although the parasite tended to occur a bit more frequently in area A, where the maximum spring-prevalence was 6.3 % in May/June '88 (WH90). The maximum January-prevalence of 5.3 % could be recorded on cruise WH103 in '90 at station 6 of area B. Looking at the overall spatial distribution of C. lingua in the North Sea, it seemed as if it was concentrated at those stations, which are nearest to the coast.
As in case of the other parasites, there are no clear signs for seasonal changes of prevalences. However, looking at the bars in area A, the spring values seemed to be elevated. In area B no such trend was present.
There is no evidence for a consistent time trend of prevalences, although the values found at stations 1, 2, 3, and 11 suggest some - although contradictory - changes during the period of this study.
Whereas prevalences at station 11 decreased, they exhibited an increasing trend at stations 1, 2, and 3.
A possible length-prevalence relationship in whiting of area A is only indicated in the spring data shown in the upper graph of Fig. 9. The number of whiting infested seemed to increase with increasing total length of the fish. Out of the January data no such trend could be noticed.

DISCUSSION

In the present paper some marked differences in the spatial distribution of L. branchialis, C. adunca, D. merlangi, and C. lingua in North Sea whiting could be shown. The findings concerning the first 3 parasites correspond well with the data provided by MÜLLER (1982) and PILCHER et al. (1989), revealing the highest prevalences for L. branchialis in the south-eastern North Sea, for C. adunca in the southern North Sea, and for D. merlangi in the northern North Sea. C. lingua, which was not investigated by the above authors, could be recorded in more coastal areas of the whole North Sea with a slight maximum in the southern part.
Although difficult to compare, due to differences in the geographical region of sampling station, sampling time, and probably length strata of whiting examined, the mean prevalences found at the different stations in the course of this study were in about the same range as in the above studies, although showing some strong fluctuations. Particularly the prevalences found in May/June '88 (WH90) and Jan.'89 (WH94) were almost generally elevated considerably, and showed much higher levels than MÜLLER (1982) and PILCHER et al. (1989) could register in their studies. Seemingly, the conditions at that time enabled an optimal development

of the parasites.

When looking for reasons for the characteristic regional distribution patterns of the 4 parasite species, several factors have to be taken into account. Out of the abiotic ones, both the salinity and the water temperature possibly may influence the spatial distribution. MÜLLER (1982) for example suggested that the decreasing prevalences of D. merlangi from the northern to the southern North Sea may be linked with the decline of salinity. In contrast, PILCHER et al. (1989) discussed the influence of the bottom temperature gradient from the northern to the southern parts of the North Sea as a possible cause for the distribution characteristics of D. merlangi.

One of the most important biotic factors is the availability of the different hosts for the parasites. In L. branchialis and C. lingua the spatial and temporal distribution is not only governed by the simultaneously occurrence of M. merlangus, but additionally by the presence or absence of intermediate hosts. In the first, the parasite can only be transmitted to the whiting via the flounder. In the latter, snails of the genus Littorina (probably mainly the common periwinkle Littorina littorea) are involved in the life-cycle. In both intermediate hosts highest population densities can be found in coastal waters (MÜLLER 1982, KOIE 1983, LAUCKNER 1984), which is probably the reason that infested whiting can be found more frequently at stations near to the coast.

As other important biotic factors, the population structure and the migratory behaviour of whiting in the North Sea have to be taken into account. From studies published by GAMBLE (1959, cit. in HISLOP and MacKENZIE 1976), MESSTORFF (1959), ROUT (1962), KABATA (1967, cit. in HISLOP and MacKENZIE 1976) and HISLOP and MacKENZIE (1976) there is strong evidence for the existence of at least two distinct whiting stocks, one distributed to the south and the other to the north of the Dogger Bank (the borderline introduced by MESSTORFF (1959) has been applied in the present study in order to avoid a mixing of results derived from the different stocks). Additionally, there is also evidence for the presence of separated coastal and offshore stocks, which could be demonstrated either by tagging experiments or by using different parasites as biological tags (SHOTTER 1973a, HISLOP and MacKENZIE 1976).

Although a fairly stationary species (MESSTORFF 1959, HISLOP and MacKENZIE 1976), whiting of different areas undertake small scaled southernly and northernly migrations (HISLOP and MacKENZIE 1976) and such from the coast to more offshore regions and vice versa (Van den BROEK 1978, 1979a,b, POTTER et al. 1988).

There is evidence, that the first infestation with L. branchialis, C. adunca, and C. lingua mainly takes place in coastal and inshore waters, which are used as nursery areas by young whiting immigrating from their more offshore breeding grounds (Van den BROEK 1978, 1979a,b, POTTER et al. 1988). When getting older, some of the whiting seem to leave their coastal habitats for more offshore areas, which may explain the findings of infested fish in the central parts of the North Sea. However, the main

part of infested whiting seems to remain in coastal areas, thus accounting for the higher prevalences found there.
In contrast to the above parasites, D. merlangi seems to establish itself in older fish (about 6 months old) of more offshore regions. SHOTTER (1973a) suggested, that these older fish become more benthic in habitat and thus get more contact either with infective oncomiracidia or older already infested fish.
It should be noted, however, that none of the stations used during the 5 cruises of this study was a real "coastal station". Thus, the differences in parasite burden between coastal and offshore whiting in most cases could only be indicated and not demonstrated clearly.

The fact that out of the prevalences recorded on single stations no clear evidence for a seasonality of infestation could be shown contradicts the findings and interpretations of PILCHER et al. (1989) comparing winter and summer data. They found significantly higher levels of infestation with L. branchialis and C. adunca and significantly lower levels with D. merlangi in winter. However, they did not use prevalences as indicator but mean intensities, and, on the other hand, their conclusions were only based on two sampling seasons (August '85 and February '86) and on a limited number of whiting examined.
Explanations for the time trends found in the present study, on the one hand revealing overall decreasing trends for the occurrence of L. branchialis and C. adunca (Fig. 2 and 3), and on the other hand a partly increasing level of C. lingua can not be provided at present.

Comparison of total length of whiting and the percent prevalences of infestation with the parasites under examination within cm-length classes revealed some interesting trends (Fig. 6-9). In L. branchialis, D. merlangi, and C. lingua there is evidence for a positive relationship, in C. adunca for a negative. Possible reasons are only hard to find, but in case of the first 3 parasites, the age-dependent increasing risk of getting into contact with the parasites may be responsible for this trend.
Explanations for the decreasing prevalence found with C. adunca are much more complex. Increasing mortality due to parasitization, changes in immunocompetence of older fish, and age-dependent differences in the ecology (including migration) of the whiting may account for this negative relationship. The latter factors speculated may also have been responsible for the decline in prevalence of D. merlangi in larger fish (Fig. 8).

LITERATURE CITED

ANSTENSRUD, M. (1989). Experimental studies of the reproductive behaviour of the parasitic copepod Lernaeocera branchialis (Pennellidae). J. mar. biol. Ass. U.K. 69: 465-476

ANSTENSRUD, M. (1990). Mating strategies of two parasitic copepods ((Lernaeocera branchialis (L.)(Pennellidae) and Lepeophtheirus pectoralis (Müller)(Caligidae)) on flounder: polygamy, sex-specific age at maturity and sex ratio. J. Exp. Mar. Biol. Ecol. 136: 141-158

ARME, C. and HALTON, D. W. (1972). Observations on the occurrence of Diclidophora merlangi (Trematoda:Monogenea) on the gills of whiting, Gadus merlangus. J. Fish Biol. 4: 27-32

HISLOP, J. R. G. and MacKENZIE, K. (1976). Population studies of the whiting Merlangius merlangus (L.) of the northern North Sea. J. Cons. int. Explor. Mer 37: 98-111

HISLOP, J. R. G. and SHANKS, A. M. (1981). Recent investigations on the reproductive biology of the haddock, Melanogrammus aeglefinus, of the northern North Sea and the effects on fecundity of infection with the copepod parasite Lernaeocera branchialis. J. Cons. int. Explor. Mer 39: 244-251

KABATA, Z. (1961). Lernaeocera branchialis (L.) a parasitic copepod from the European and the American shores of the Atlantic. Crustaceana 2: 243-249

KABATA, Z. (1963). Clavella (Copepoda) parasitic on British gadidae: one species or several ? Crustaceana 5: 64-74

KABATA, Z. (1967). Whiting stocks and their gall-bladder parasites in British waters. Mar. Res.: 11 pp.

KABATA, Z. (1981). Copepoda (Crustacea) parasitic on fishes: problems and perspectives. Adv. Parasit. 19: 1-71

KABATA, Z. (1984). Diseases caused by metazoans: Crustaceans. In: Diseases of marine animals (Vol. IV). KINNE, O. (ed.). Hamburg, BAH: 321-399

KOIE, M. (1983). Digenetic trematodes from Limanda limanda (L.) (Osteichthyes, Pleuronectidae) from Danish and adjacent waters, with special reference to their life-histories. Ophelia 22: 201-228

KOIE, M. (1984). Digenetic trematodes from Gadus morhua L. (Osteichthyes, Gadidae) from Danish and adjacent waters, with special reference to their life-histories. Ophelia 23: 195-222

LAUCKNER, G. (1984). Brackish-water submergence of the common periwinkle, Littorina littorea, and its digenean parasites in the Baltic Sea and in the Kattegat. Helgoländer Meeresunters. 37: 177-184

LLEWELLYN, J. (1956). The host specifity, micro-ecology, adhesive attitudes and comparative morphology of some trematode gill parasites. J. mar. biol. Ass. U.K. 35: 113-127

LLEWELLYN, J. (1958). The adhesive mechanism of monogenetic trematodes: the attachment of species of diclidophoridae to the gills of gadoid fishes. J. mar. biol. Ass. U.K. 37: 67-79

LLEWELLYN, J. and TULLY, C. M. (1969). A comparison of speciation in diclidophorinean monogenean gill parasites and their fish hosts. J. Fish. Res. Bd. Canada 26: 1063-1074

MANN, H. (1952). Lernaeocera branchialis (Copepoda parasitica) und seine Schadwirkung bei einigen Gadiden. Arch FischWiss. 4: 133-144

MESSTORFF, J. (1959). Untersuchungen über die Biologie des Wittlings Merlangius merlangus (L.) in der Nordsee. Ber. Dtsch. Wiss. Komm. Meeresforsch. 14: 277-334

MÜLLER, H. (1982). Biologie, Verbreitung und Schadwirkung auffälliger Ektoparasiten an Fischen der Nordsee und westlichen Ostsee. Diplom Thesis, Univers. of Kiel, F.R.G.: 90 pp.

PILCHER, M. W., WHITFIELD, P. J. and RILEY, J. D. (1989). Seasonal and regional infestation characteristics of three ectoparasites of whiting, Merlangius merlangus L., in the North Sea. J. Fish Biol. 35: 97-110

POTTER, I. C., GARDNER, D. C. and CLARIDGE, P. N. (1988). Age composition, movements, meristics and parasites of the whiting, (Merlangius merlangus), in the Severn estuary and Bristol Channel. J. mar. biol. Ass. U.K. 68: 295-313

POULSEN, E. K. (1939). Investigations upon the parasitic copepod Clavella uncinata (O. F. Müller) in Danish waters. Vidensk. Meddr. dansk naturh. Foren. 102: 223-244

ROUT, D. W. R. (1962). Some observations on the whiting (Gadus merlangus L.) of the inshore winter fishery off Lowestoft. J. Cons. perm. int. Explor. Mer 27: 316-324

SCHUURMANS STEKHOVEN, J. H. (1936). Beobachtungen zur Morphologie und Physiologie der Lernaeocera branchialis und Lernaeocera lusci, B. S. (Crustacea parasitica). Z. Parasitenk. 8: 659-696

SCHUURMANS STEKHOVEN, J. H. and PUNT, A. (1937). Weiter Beiträge zur Morphologie und Physiologie der Lernaeocera branchialis L. Z. Parasitenk. 9: 648-667

SHOTTER, R. A. (1971). The biology of Clavella uncinata (Müller) (Crustacea:Copepoda). Parasitology 63: 419-430

SHOTTER, R. A. (1973a). A comparison of the parasite fauna of young whiting, Odontogadus merlangus L. (Gadidae) from an inshore and offshore location off the Isle of Man. J. Fish Biol. 5: 185-195

SHOTTER, R. A. (1973b). Changes in the parasitic fauna of whiting, Odontogadus merlangus L., with age and sex of host, season, and from different areas in the vicinity of the Isle of Man. J. Fish Biol. 5: 559-573

SMITH, J. W. (1969). The distribution of one monogenean and two copepod parasites of whiting, Merlangius merlangus L., caught in British waters. Nytt Mag. Zool. 17: 57

SPROSTON, N. G. and HARTLEY, P. H. T. (1941). Ecology of some parasitic copepods of gadoid and other fishes. J. mar. biol. Ass. U.K. 25: 361-392

STUNKARD, H. W. (1930). The life-cycle of Cryptocotyle lingua (Creplin), with notes on the physiology of the metacercariae. J. Morph. 50: 143-183

SUNDNES, G. (1971). Lernaeocera branchialis (L.) on cod (Gadus morhua) in Norwegian waters. Institute of Mar. Res., Bergen: 48 pp.

Van den BROEK, W. L. F. (1978). The effects of Lernaeocera branchialis on the Merlangius merlangus population in the Medway estuary. J. Fish Biol. 13: 709-713

Van den BROEK, W. L. F. (1979a). Infection of estuarine fish populations by Cryptocotyle lingua (Creplin). J. Fish Biol. 14: 395-402

Van den BROEK, W. L. F. (1979b). Copepod parasites of Merlangius merlangus and Plathichthys flesus. J. Fish Biol. 14: 371-380

WERDING, B. (1969). Morphologie, Entwicklung und Ökologie digener Trematoden-Larven der Strandschnecke Littorina littorea. Mar. Biology 3: 306-333

Tab.1: Code of sampling stations and number of whiting examined per cruise and station
(0 = no whiting caught, – = no sampling)

Station	WH90 May/June 1988	WH94 Jan. 1989	WH98 May/June 1989	WH103 Jan. 1990	WH107 May 1990
1	104	126	449	233	270
2	52	54	263	485	535
3	144	41	287	276	323
4	76	116	328	0	381
5	265	17	134	299	911
5a	–	–	96	–	680
6	64	35	296	510	787
7	81	108	280	300	692
7a	–	165	64	336	–
8	72	76	260	173	489
8a	–	–	214	–	–
9	43	–	163	85	623
10	101	–	97	–	406
10a	–	–	335	–	–
11	64	0	254	538	338
Σ	1066	738	3520	3235	6435

Tab.2: Number of whiting per cruise and cm total length examined for the occurrence of parasites in areas A and B

	WH90 May/June 1988		WH94 Jan. 1989		WH98 May/June 1989		WH103 Jan. 1990		WH107 May 1990	
cm	A	B	A	B	A	B	A	B	A	B
10	-	-	1	1	2	1	9	-	3	1
11	4	-	3	-	3	2	30	-	2	4
12	17	1	5	2	4	4	61	7	13	21
13	18	-	5	11	5	10	126	15	26	70
14	24	9	2	16	13	33	198	35	49	127
15	24	12	5	11	29	96	241	60	92	154
16	20	26	6	8	37	152	173	122	159	218
17	20	19	9	7	33	164	118	99	193	212
18	39	20	18	4	44	119	75	65	172	104
19	31	41	18	4	59	124	52	61	149	140
20	39	51	28	8	84	84	39	126	153	247
21	30	60	28	3	137	58	57	199	136	356
22	38	48	32	14	181	50	79	174	158	388
23	38	37	33	37	186	65	62	135	162	286
24	40	29	27	39	280	76	77	96	162	243
25	31	23	37	34	213	94	45	78	202	244
26	30	25	22	49	148	103	45	75	141	194
27	28	24	20	42	107	113	19	76	91	158
28	30	24	16	41	84	109	13	64	80	112
29	11	16	5	28	50	72	7	48	38	98
30	14	7	11	20	34	63	3	32	30	64
31	3	5	-	10	15	42	2	21	10	39
32	5	2	4	4	11	33	1	12	14	34
33	1	-	-	3	7	20	-	5	6	20
34	1	1	1	3	5	9	-	6	6	13
35	2	2	-	3	2	5	-	4	-	3
36	-	-	-	-	-	4	-	-	-	5
37	3	-	-	-	1	3	-	-	2	2
38	-	-	-	-	-	4	-	1	-	1
39	-	-	1	-	-	1	-	1	2	-
40	-	-	-	-	-	-	-	-	1	-
Σ	541	482	336	402	1683	1701	1532	1615	2247	3550
ΣΣ	1023		738		3384		3147		5797	

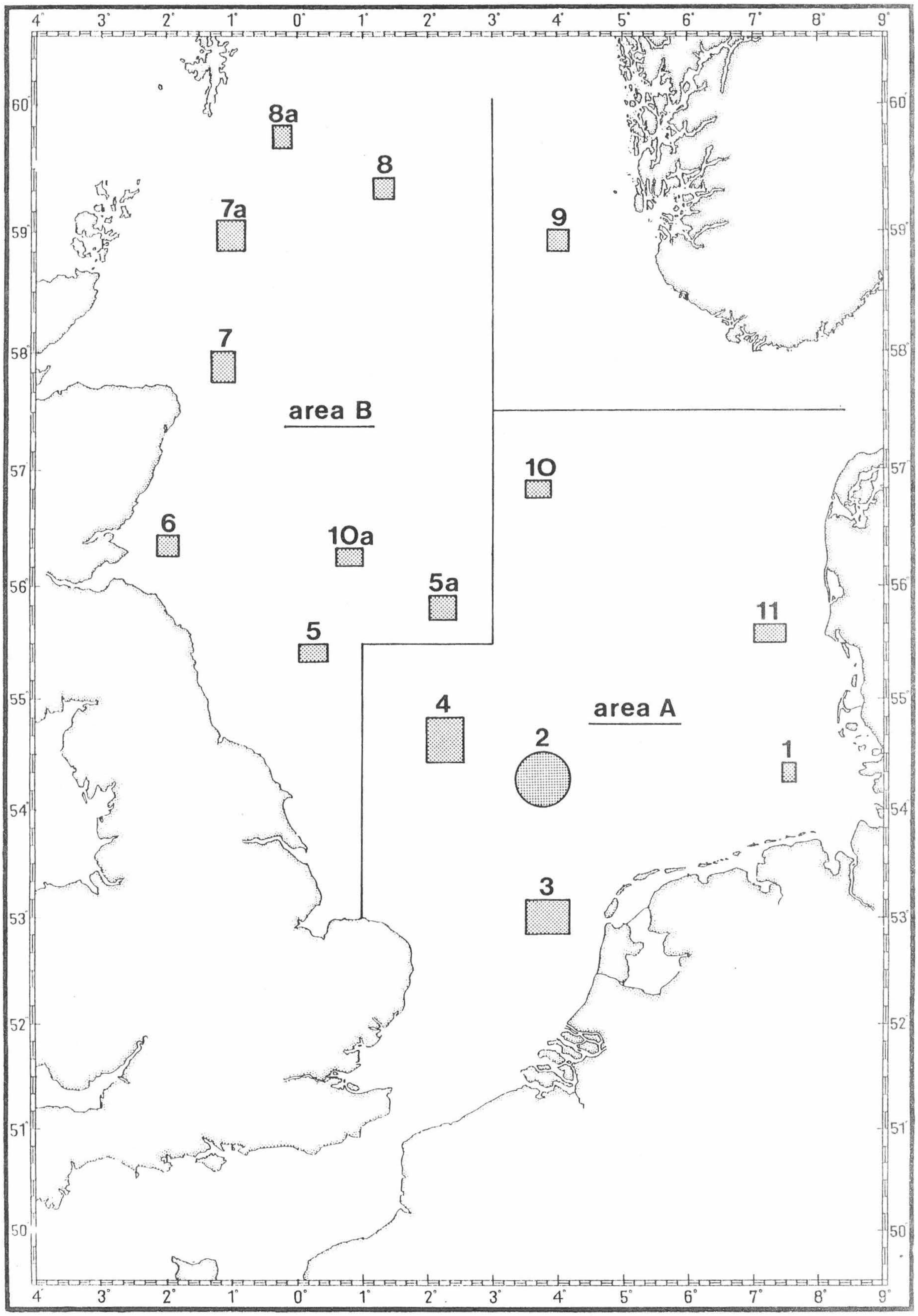

Fig. 1: Location and size of sampling stations in areas A and B

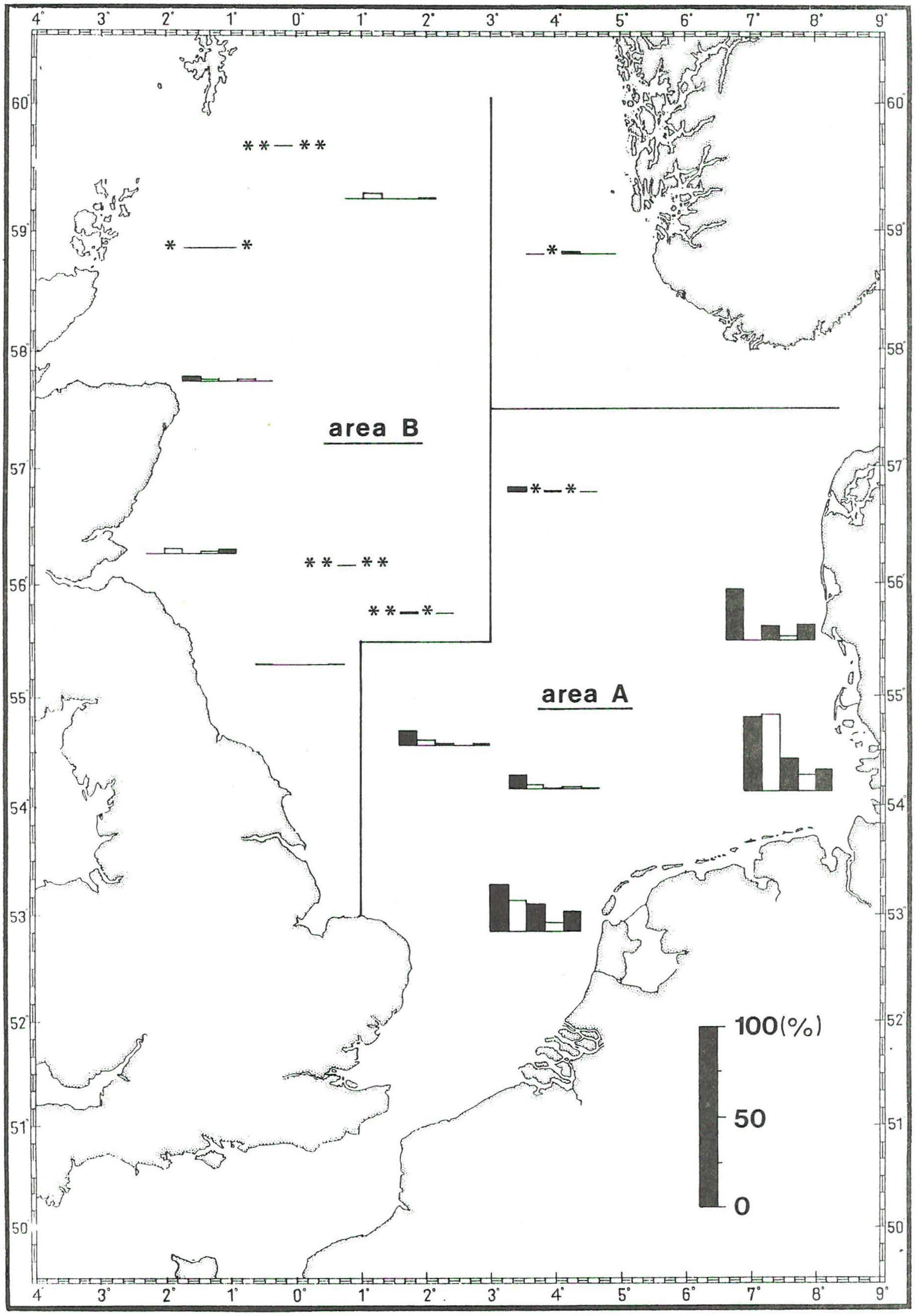

Fig. 2: Prevalences of infestation with **Lernaeocera branchialis** in whiting of different cruises, areas, and stations (bars from left to right: WH90, WH94. WH98, WH103, WH107: dark bars: spring, light bars: winter)

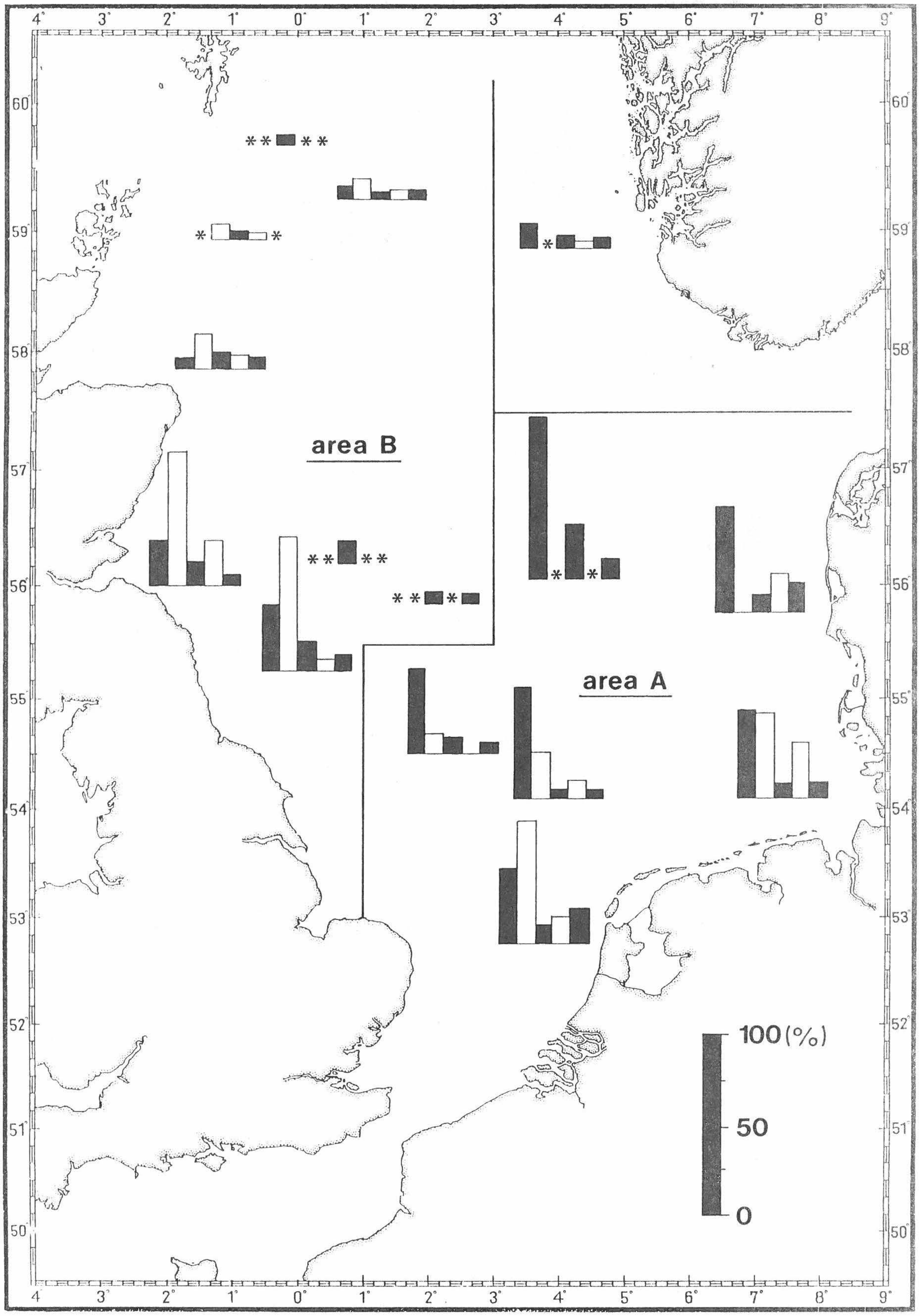

Fig. 3: Prevalences of infestation with **Clavella adunca** in whiting of different cruises, areas, and stations (bars from left to right: WH90, WH94, WH98, WH103, WH107; dark bars: spring, light bars: winter)

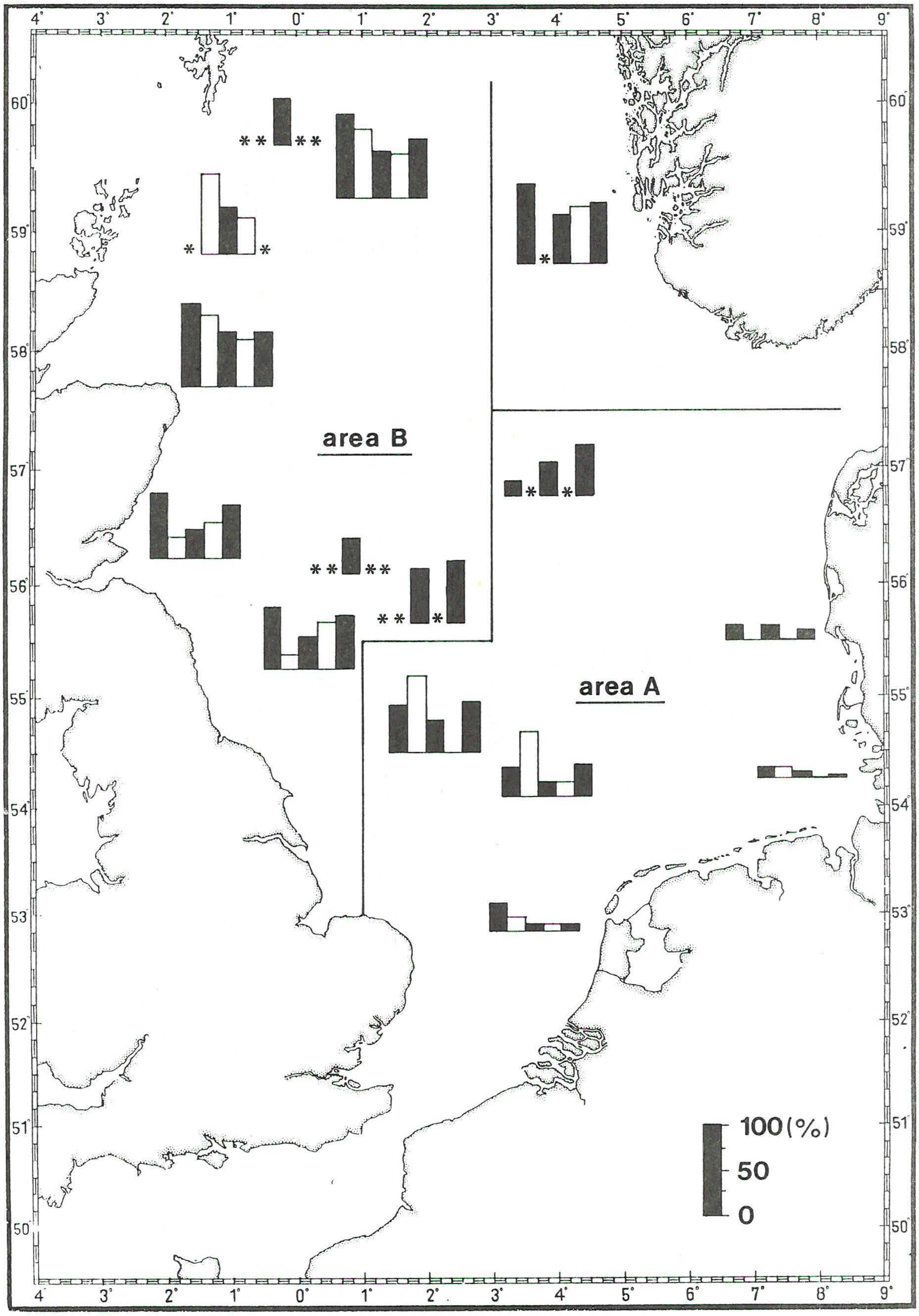

Fig. 4: Prevalences of infestation with **Diclidophora merlangi** in whiting of different cruises, areas, and stations (bars from left to right: WH90, WH94, WH98, WH103, WH107: dark bars: spring, light bars: winter)

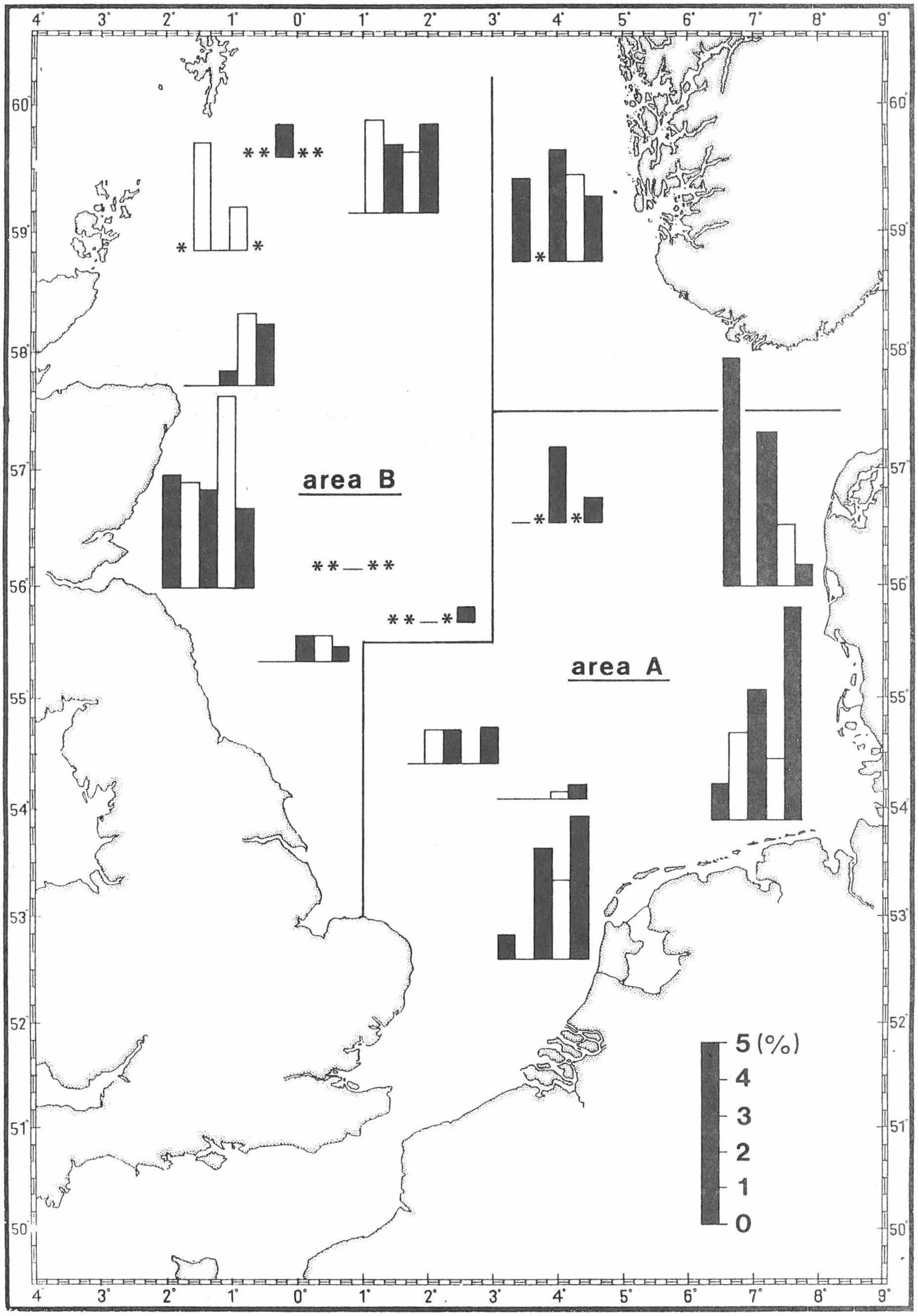

Fig. 5: Prevalences of infestation with **Cryptocotyle** lingua in whiting of different cruises, areas, and stations (bars from left to right: WH90, WH94, WH98, WH103, WH107; dark bars: spring, light bars: winter)

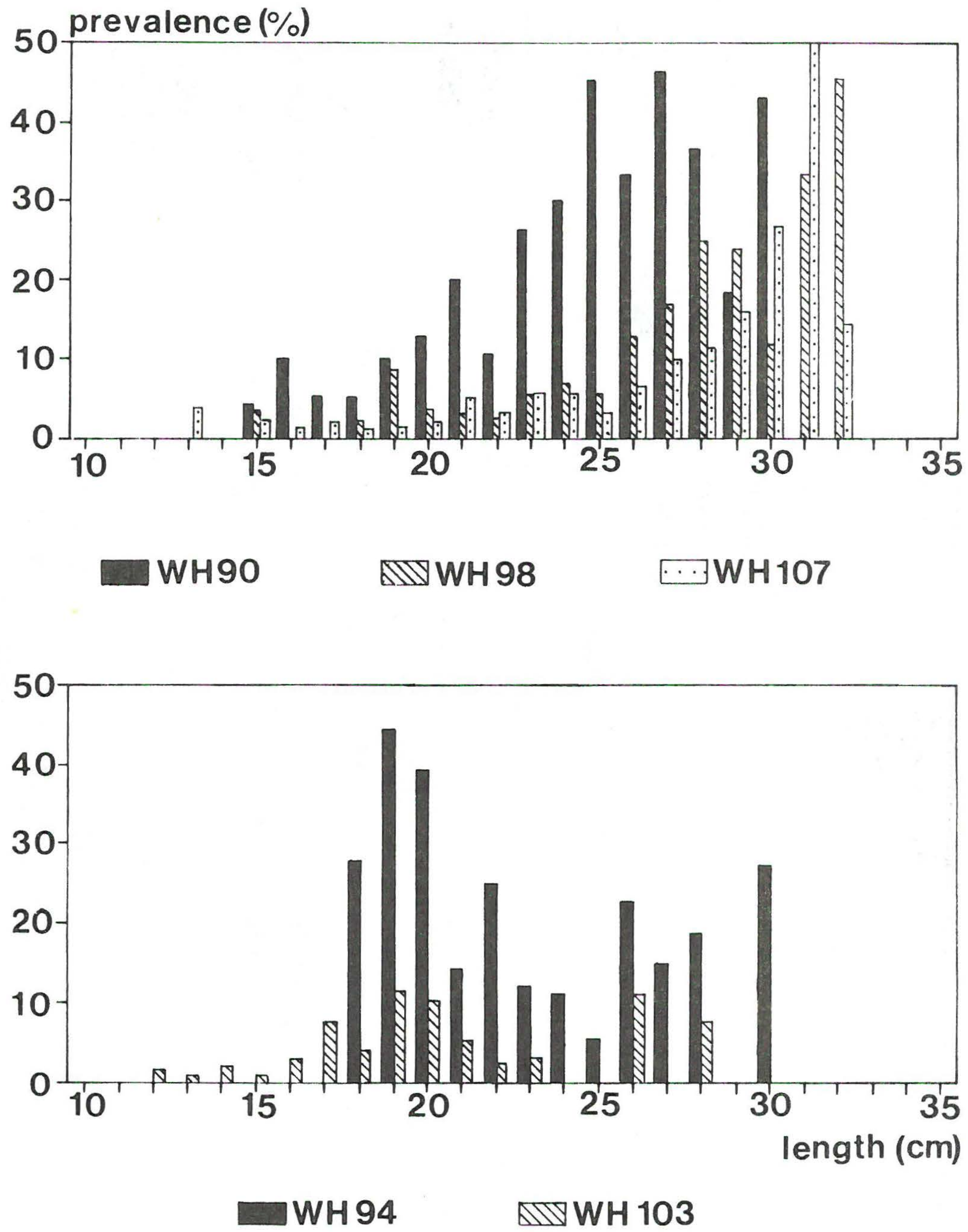

Fig. 6: Length-prevalence relationship in whiting of area A infested by **Lernaeocera branchialis** (upper graph: spring; lower graph: winter)

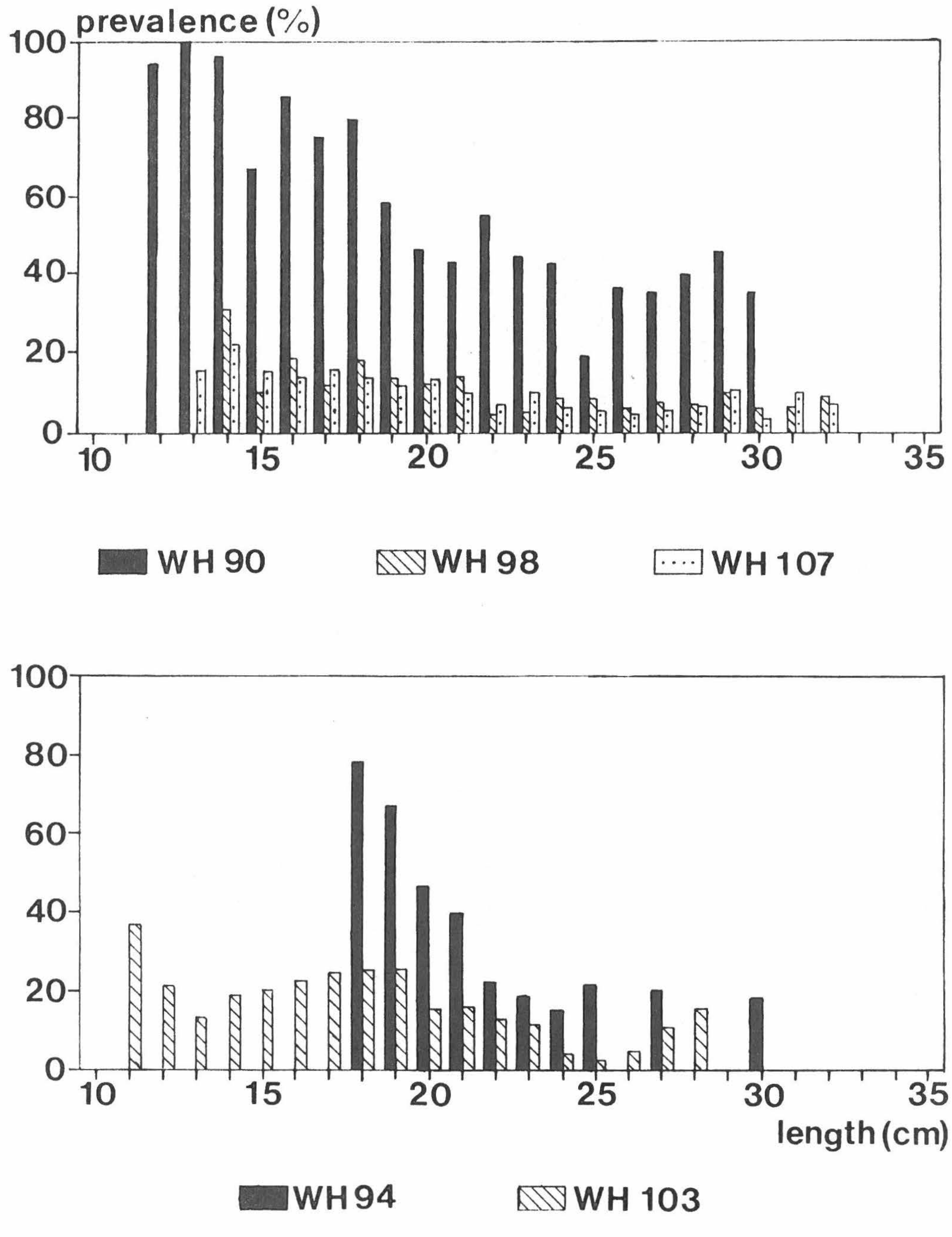

Fig. 7: Length-prevalence relationship in whiting of area A infested by **Clavella adunca** (upper graph: spring; lower graph: winter)

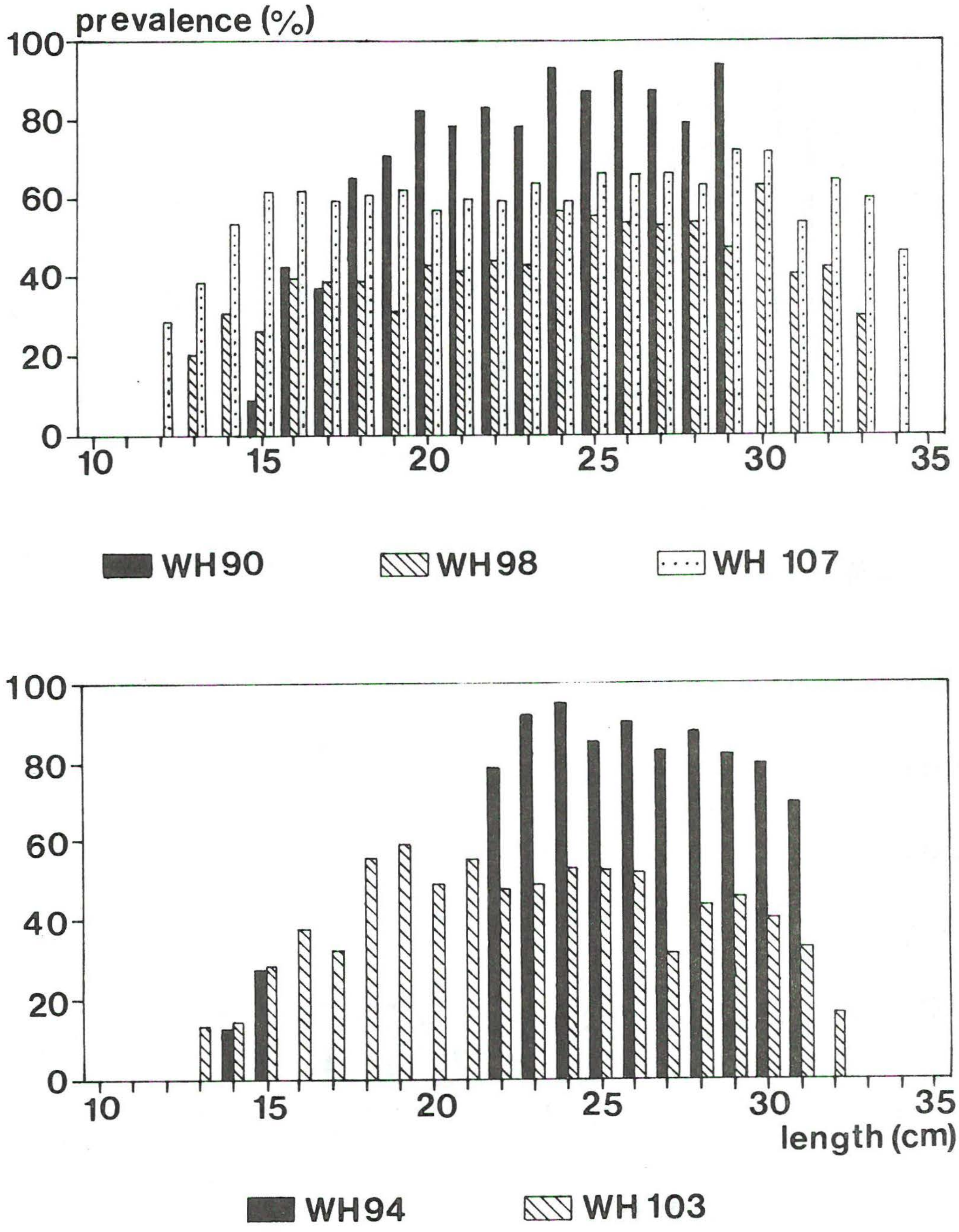

Fig. 8: Length-prevalence relationship in whiting of area B infested by **Diclidophora merlangi**
(upper graph: spring; lower graph: winter)

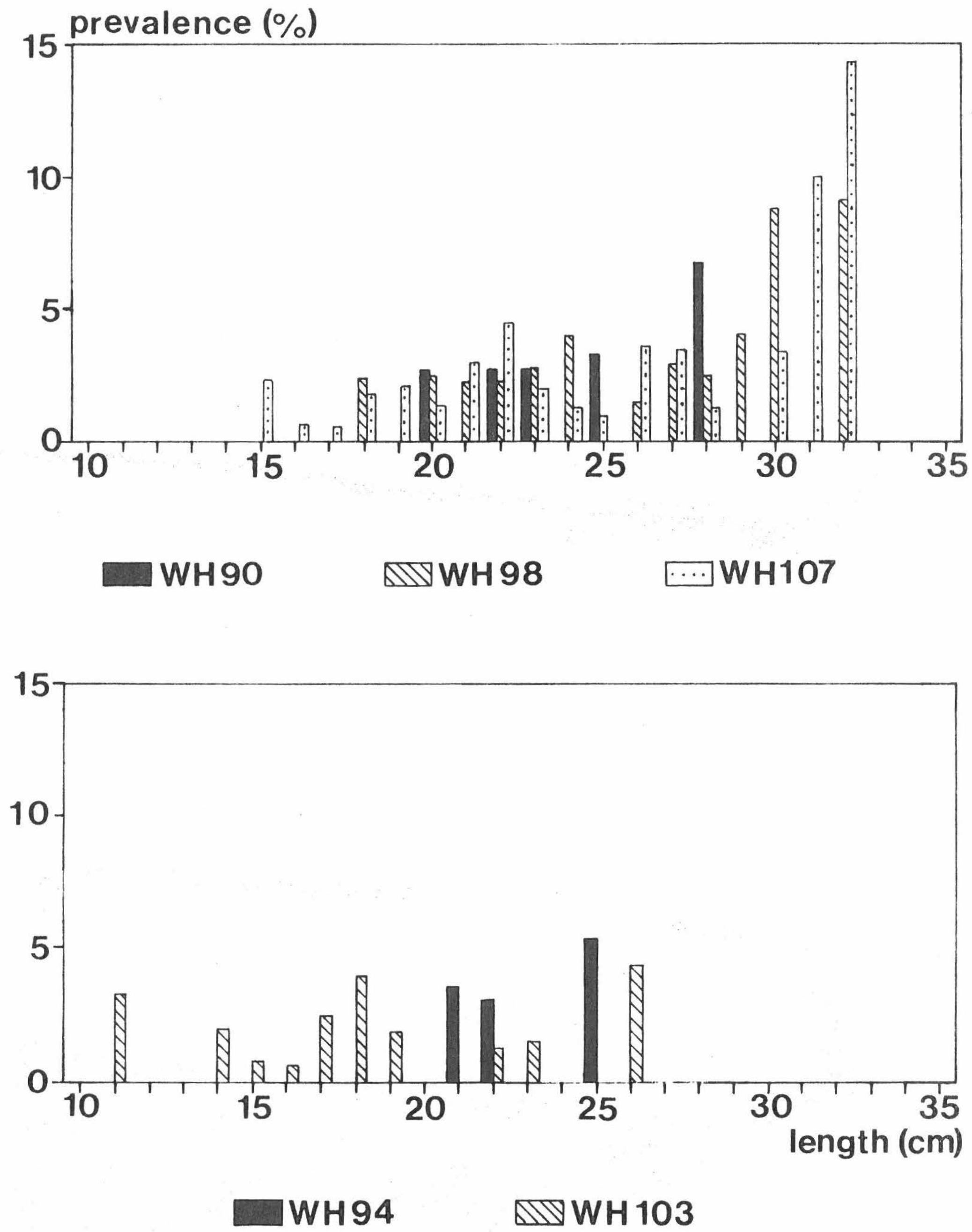

Fig. 9: Length-prevalence relationship in whiting of area A infested by **Cryptocotyle lingua** (upper graph: spring; lower graph: winter)