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Some effects of double beam trawling

by

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INTRODUCTION

This report concerns observations made on the Outer Morecambe Bay (Liverpool Bay or north-east Irish Sea) fishing grounds between 26 and 29 April 1971 at the height of the international fishery for soles by double beam trawlers. The aim of the project was to assess the effect on life in the sea by this fishery and was not concerned with either the effects on the sea bed or with the long-term effects on fish stocks. The aim was achieved by comparing the catches of a Dutch beam trawler with those of two otter trawlers fishing on the same grounds as the beam trawl fleet and also on grounds which were not fished by the beam trawlers.

METHODS

Observations were made on three vessels by Ministry scientists: (1) MV ENNIE EN APPIE: a Dutch commercial vessel, 27 m in length, 700 horsepower, fishing two 9.5 m beam trawls, each of which carried ten 15 mm diameter tickler chains from the trawl heads and seven 12 mm tickler chains from the groundrope. The groundrope was 28 m long, of 15 mm chain wrapped with rope and chain to a diameter of 25 cm for 8 m in the bosom. The cod-end was double-braided nylon of 75 mm mesh size; (2) MV SILVER STAR: a Welsh commercial vessel, 15 m in length, 175 horsepower, fishing an otter trawl with a 20 m headline, 46 m double bridles and no tickler chains. The groundrope was 26 m long made of chain threaded with 8 cm rubber discs. The cod-end was single polyethylene of 72 mm mesh size, covered on top with shrimp netting (19 mm) for the purpose of the project; (3) RV CLIONE: an English research vessel, 43 m in length, 1 060 horsepower, fishing a 'Granton' otter trawl with a 24 m headline, no tickler chains and a 37 m chain and rubber disc groundrope. The cod-end was double polyethylene of 75 mm mesh size, covered on top with shrimp netting (19 mm).

Observations covered day and night fishing at all states of the tides and included 29 hauls of both beams by ENNIE EN APPIE (40.58 hours fishing, average haul duration 1.40 hours), 10 hauls by SILVER STAR (25.33 hours, 2.53 hours) and 9 hauls by CLIONE (10.35 hours, 1.15 hours). The position of each haul is shown in Figure 1. SILVER STAR and ENNIE EN APPIE fished between 26 and 28 April and CLIONE on 28 and 29 April. Radio contact was maintained during the project, and the relative positions of the vessels were coordinated.

The catch of fish, benthic invertebrates and bottom debris was recorded for each haul. Soles and plaice were measured on ENNIE EN APPIE and soles, plaice, dabs, whiting and cod on SILVER STAR. The extent and type of damage to soles and plaice was recorded according to the following scale:

GENERAL CONDITION	1. Lively; slimy; good muscle tone
	2. Alive; little slime; poor muscle tone
	3. Dead or almost so; no slime; no muscle tone
SCALE DAMAGE (dorsal surface)	0. No scales lost
	1. Less than 5 per cent lost
	2. Between 5 and 40 per cent lost
	3. More than 40 per cent lost
BRUISING (ventral surface)	0. No bruises
	1. Less than 5 per cent heavily bruised (red appearance) or up to 50 per cent superficially bruised (pink appearance)
	2. Between 5 and 40 per cent heavily bruised or between 50 and 100 per cent superficially bruised
	3. More than 40 per cent heavily bruised
WOUNDS	0. No cuts or lacerations
	1. A few small cuts
	2. Numerous small cuts or one severe cut or wound
	3. Very severe, very numerous or very deep cuts or wounds

Quick assessments of the extent of damage to other species of fish and the invertebrates were also made. Photographs were taken whenever possible and samples of damaged fish preserved to ensure that the condition and damage criteria used on each vessel were comparable.

In addition, oxygen and salinity samples from 4 m above the bottom were taken at 11 stations by CLIONE and the values obtained were within the expected range. Attempts were made to photograph the sea bed, using a camera and flash-unit attached to the trawl headline, but owing to the turbidity no results were obtained.

RESULTS

The amount of fishing by the three vessels and overall catch-rates of fish, benthic invertebrates and bottom debris (in $\frac{1}{4}$ cran baskets per hour's fishing) are shown in Table 1. The catch-rates and percentage of different species of fish in the catches of each vessel are shown in Table 2.

Table 1 Summary of fishing operations

	ENNIE EN APPIE		SILVER STAR		CLIONE	
Number of hauls	29		10		9	
Total hours fishing	40.58		25.33		10.35	
Average duration of hauls (hours)	1.40		2.53		1.15	
	Catch, as baskets per hour and as percentage of total catch					
	Catch	%	Catch	%	Catch	%
Cod-end						
Fish	3.8	25	1.7	84	0.8	57
Invertebrates	8.9	58	0.1	8	0.6	40
Debris	2.6	17	0.2	8	0.1	3
Total	15.3		2.0		0.5	
Cover						
Fish	NA		0.5	100	0.5	100
Invertebrates	NA		0	0	0	0
Debris	NA		0	0	0	0
Total	NA		0.5		0.5	

Table 2 Species composition of the catch of each vessel

Species	Kg/hour			Number/hour			% by weight		
	EA*	SS*	C*	EA	SS	C	EA	SS	C
Cod-end									
Sole (Solea solea)	63.8	4.4	1.9	344	24	10	50.4	8.4	11.8
Plaice (Pleuronectes platessa)	25.9	18.0	3.9	79	55	12	20.5	34.4	24.2
Dab (Limanda limanda)	16.0	18.6	5.1	175	203	56	12.6	35.6	31.7
Whiting (Merlangius merlangus)	6.5	7.4	3.9	38	41	22	5.1	14.1	24.2
Cod (Gadus morhua)	5.2	2.9	0.5	14	9	5	4.1	5.6	3.1
Others (70% small gadoids)	9.3	1.0	0.8	-	-	14	7.3	1.9	5.0
TOTAL	126.7	52.3	16.1						
Cover									
Sole		0.43	0		4.6	0		2.8	0
Plaice		0.02	0		0.2	0		0.1	0
Dab		4.52	+		149.4	+		29.8	+
Whiting		3.89	+		147.3	+		25.7	+
Cod		0	0		0	0		0	0
Others (90% small gadoids)		6.30	+		-	+		41.6	+
TOTAL		15.6	14.69						

*EA = ENNIE EN APPIE, SS = SILVER STAR, C = CLIONE.

'Other' fish in the cod-end and cover catches were respectively 70 and 90 per cent by weight of small gadoids - Trisopterus minutus (poor cod), T. luscus (bib) and T. esmarkii (Norway pout), but also included Eutrigla spp. (gurnards), Pollachius virens (saithe), Melanogrammus aeglefinus (haddock), Merluccius merluccius (hake), Lophius piscatorius (angler), Zeus faber (John Dory), Platichthys flesus (flounder), Buglossidium luteum (solenette), Scophthalmus maximus (turbot), S. rhombus (brill), Raja clavata (thornback ray) and Scyliorhinus caniculus (lesser spotted dogfish). No further details were recorded for these species except that all appeared to be in normal condition for trawl-caught fish on SILVER STAR and CLIONE, and were slightly less damaged (scaled) than on ENNIE EN APPIE.

1 Sole

SILVER STAR was outfished 14.5 to 1 by weight by ENNIE EN APPIE on sole (cod-end only). The length composition of the catch of these vessels is plotted in Figure 2. This shows that the selective action of the cod-end mesh in use on the beam trawl was apparently the same as that of the cod-end on the otter trawl. The proportions of released and retained, undersized and above minimum legal size (24 cm) soles in SILVER STAR's catch were as in Table 3.

Table 3 Size composition of soles caught by MV SILVER STAR

Size-group (cm)	Cod-end catch		Cover catch		Total population	
	Number	% of total population	Number	% of total population	Number	%
< 24	92	17.8	70	13.5	162	31.3
> 24	332	64.2	23	4.5	355	68.7
Total	424	82.0	93	18.0	517	100

Table 4 compares the percentages of the total cod-end catch of sole in various condition categories for ENNIE EN APPIE and SILVER STAR, and also the percentages in the cover catch of SILVER STAR. In all four categories of damage, a greater proportion of soles caught by ENNIE EN APPIE was given a higher code number than those caught by SILVER STAR, and this was confirmed by comparison of photographs. The biggest difference between the two vessels was in the greater extent of scale damage to soles caught by the beam trawler. The 'general condition'

categories are thought to be of limited value for comparison, because the condition of the fish deteriorated between the time of capture and the time of measurement, and standardization could not be achieved.

Table 4 Sole condition and damage categories

	Vessel		Code number			
			0	1	2	3
General condition	EA	Cod-end	-	18	45	37
	SS	Cod-end	-	35	38	27
	SS	Cover	-	15	44	41
Scale damage	EA	Cod-end	24	28	30	18
	SS	Cod-end	13	53	25	8
	SS	Cover	21	41	29	9
Bruising	EA	Cod-end	18	42	26	14
	SS	Cod-end	18	55	23	4
	SS	Cover	13	46	33	8
Wounds	EA	Cod-end	93	3	1	3
	SS	Cod-end	97	2	1	0
	SS	Cover	98	0	0	2

Number of fish: EA 343; SS 348 (cod-end) and 61 (cover)

The percentage of soles which had the highest code number in each category of damage is plotted against length in Figure 3 (ENNIE EN APPIE). General condition improved with increasing length and the extent of scale damage and wounding decreased, whereas the extent of bruising was greater in the larger fish. Cover-caught soles on SILVER STAR were, on average, slightly more damaged than those caught in the cod-end. This may be a parallel of the length/damage relationship found for the soles caught by ENNIE EN APPIE.

There were significant positive correlations between the percentage of fish in the worst categories of scale damage, bruising and wounding and the 'rubbish' index (volume of vertebrates and debris divided by the volume of fish in the total catch) (Fig. 4). The analysis has been restricted to samples from six hauls, all from approximately the same sandy area in which the invertebrate species (Corystes dominant) and debris types (mainly shell) were the same and varied only in quantity between hauls. One further haul was from a muddy sand area in which the rubbish index was high and damage low; but the rubbish composition was different in that it consisted mainly of a muddy sand and Echinocardium caudatum.

A further category of damage/condition which was recognized during the project as sufficiently distinct to warrant separate treatment was the presence of so-called 'rotten' fish which lacked a large proportion of their skin on both surfaces, exposing areas of decomposing flesh. Four out of 603 caught in the cod-end of SILVER STAR were in this category (0.63 per cent), 2 out of 106 (1.9 per cent) on CLIONE and an estimated 400 out of 13 977 caught on ENNIE EN APPIE (2.9 per cent). One of these had been gutted (CLIONE), although this feature could have been more frequent since it may have been overlooked on the other vessels. The length composition of 'rotten' fish (ENNIE EN APPIE) is shown in Figure 2. Although only 63 fish were measured (and not very accurately because they were in varying states of decomposition), the length composition is obviously different from that of the apparent total population in that it contains a relatively low proportion of fish above 24 cm.

2 Plaice

SILVER STAR was outfished by 1.44 to 1 by weight by ENNIE EN APPIE on plaice (cod-end catches). The length compositions are shown in Figure 5. It is likely that the proportion of large plaice caught by ENNIE EN APPIE was underestimated because these were retained in one basket and those from different hauls were not kept separately. At least 70 per cent of above legal minimum size plaice were rejected on ENNIE EN APPIE when the observer was aboard (first two days of a six-day trip) because they were too small to be marketable in Holland and fish-hold capacity was left clear for the more profitable soles until nearer the date of landing.

The length composition of SILVER STAR's cod-end plus cover catches represents that of the total population on the grounds. The mean selection length of plaice for a 75 mm mesh is about 16.5 cm, but only 5 out of 1 362 of the plaice entered the cover. Of the total population 30.8 per cent were below minimum size (25 cm) and 69.2 per cent were of legal size; an estimated 70 per cent of the latter were rejected by the beam trawler.

Percentages of plaice in the various damage categories are shown in Table 5. In all four categories of damage a greater proportion of plaice caught by ENNIE EN APPIE were given higher code numbers than those caught by SILVER STAR. Plaice were in a worse condition on capture than soles in all cases.

Table 5 Plaice condition and damage categories

	Vessel	Code number			
		0	1	2	3
General condition	EA	-	0	11	89
	SS	-	8	64	28
Scale damage	EA	1	32	48	19
	SS	4	45	42	9
Bruising	EA	7	25	37	31
	SS	6	57	28	9
Wounds	EA	95	3	2	0
	SS	98	1	1	0

'Rotten' and dead fish of all sizes were seen on all vessels - 1.4 per cent on SILVER STAR (18 in 1 212 observed), CLIONE 1.6 per cent (2 in 124), and an estimated similar percentage on ENNIE EN APPIE (not measured) - but the numbers were so small that the length composition could not be accurately determined.

3 Dab

SILVER STAR outfished ENNIE EN APPIE by 1.16 to 1 by weight on dabs (cod-end catches). The length composition of SILVER STAR's catch is shown in Figure 6A. That of ENNIE EN APPIE was not measured but, assuming that the length composition of ENNIE EN APPIE's catch was the same as that of SILVER STAR, 54 per cent of the total dab population would have been retained by the cod-end and 46 per cent released. Condition of dabs and damage to them was not accurately recorded on any vessel, but 106 out of 5 130 (2.6 per cent) caught by SILVER STAR were dead on capture, though none were 'rotten' fish. Four out of 578 caught by CLIONE were dead on capture (0.7 per cent) and one of the remainder was reported as being badly scale-damaged, but otherwise the fish were in very good condition in all respects. Dabs caught by ENNIE EN APPIE were immediately rejected after capture, irrespective of size, and were therefore not closely scrutinized.

4 Whiting and cod

Length compositions of these species caught by SILVER STAR are shown in Figures 6B and 6C. Cod less than about 40 cm and whiting less than 35 cm were rejected on ENNIE EN APPIE. Condition was normal for trawl-caught fish on the otter trawlers. One whiting out of 1 040 was

caught dead by SILVER STAR and one out of 223 by CLIONE. Unfortunately, no observations were made on the beam trawler because of practical difficulties.

5 Invertebrates and debris

Whereas SILVER STAR caught 0.15 and CLIONE 0.57 baskets of invertebrate animals per hour, ENNIE EN APPIE caught 8.87 baskets per hour (4.43 per net). ENNIE EN APPIE also 'outfished' the otter trawlers on debris (shell, mud, sand and rock) by 2.64 baskets/hour (1.32 per net) compared with 0.16 baskets/hour by SILVER STAR and 0.05 baskets/hour by CLIONE. No benthos was caught in SILVER STAR's cod-end cover.

Apart from the differences in quantity there were very evident dissimilarities in the species composition of the invertebrate catch between the beam trawler and the otter trawlers. In Table 6 the most abundant species in the catches have been divided into three groups according to their habit of living in relation to the bottom sediment, i.e. those which live on it (epifauna) or in it (infauna) and those which live partially buried or closely adhered to it and which have been classified sometimes as infauna and sometimes as epifauna (Jones 1940, Jones 1952). A fourth group includes all the 'rarer' species in the catches. (It should be noted that a 75 mm mesh will release a high proportion of small animals and therefore many bivalve, polychaete and crustacean species will not have been represented.)

Table 6 Percentage invertebrate catch composition

	ENNIE EN APPIE	SILVER STAR	CLIONE
A EPIFAUNA			
Buccinum undatum/*Neptunia* spp. (adults and egg masses) *Eupagurus bernhardus* *Metridium senile* *Asterias rubens*	27	90	70
B INFAUNA			
Acanthocardia echinata *Echinocardium caudatum*	20	2	5
C PARTIALLY BURIED SPECIES			
Corystes cassivelaunus *Astropecten irregularis* *Ophiura* sp.	45	5	20
D 'RARER' SPECIES	8	3	5

The beam trawler's catch contained a relatively higher proportion of buried or partially buried species than those of the otter trawlers, whose catches consisted almost entirely of non-burrowing species, particularly those of SILVER STAR.

The beam trawler's catch of invertebrates and debris varied from haul to haul. Two hauls corresponded with the edge of an area of muddy sand recorded during a geological survey of the area (Cronan 1969) at 54°08'N 3°45'W, in which ENNIE EN APPIE's invertebrate catch consisted of 30 per cent each of Echinocardium caudatum and Corystes cassivelaunus - see Figure 1, hauls marked M. The remaining 27 hauls were on sand, or sand with some gravel, in the rectangle 54°11'N 3°58'W, 54°12'N 3°50'W, 53°47'N 3°35'W, 53°45'N 3°44'W, in which the dominant species were C. cassivelaunus and Astropecten irregularis (15 per cent of the catch each). Acanthocardia echinata comprised a further 10 per cent both north of 54°05'N and south of 53°47'N, and Ophiura 15-20 per cent between these latitudes. The catch of debris (mainly empty shells) also varied in quantity between hauls and made up as much as 40 per cent of the total catch near 50°56'N 3°46'W (total catch 13.7 baskets/hour, i.e. 2.3 baskets/hour fish, 5.7 baskets/hour invertebrates and 5.7 baskets/hour debris).

The extent of damage to different species of invertebrates by the beam trawler varied with both the quantity of the catch and its composition. In the hauls from the muddy sand area, 70 per cent of Echinocardium were damaged. In the hauls from the sandy area the extent of damage to individual species varied with the quantity of empty shells caught with them. For example, 40 per cent of Corystes were damaged when few shells were caught and 70 per cent when large quantities of shells were caught. Comparable values for Astropecten were 5 and 15 per cent, Ophiura sp. 90 and 100 per cent, Buccinum 0 and 10 per cent, Acanthocardia 5 and 30 per cent and Asterias 0 and 5 per cent.

On the otter trawlers damage was much less in all cases, and was estimated as a maximum of 20 per cent for Corystes and 40 per cent for Ophiura sp., when these were caught. Buccinum/Neptunia, Asterias and Eupagurus were all undamaged.

DISCUSSION

The similarity of the length compositions of soles and plaice caught by ENNIE EN APPIE and SILVER STAR indicates that the selective action of the 75 mm cod-end on the beam trawler was not appreciably restricted by the larger quantities of debris and invertebrates in the catch.

The beam trawler had higher catch-rates of flatfish (particularly soles) than the two otter trawlers and comparable catch-rates of round-fish. The beam trawl also caught more buried or partially buried invertebrates. These two facts show that a beam trawl with multiple ticklers disturbs the sea bed to a greater depth than a light otter trawl without ticklers. Judging from the quantities of Acanthocardia and Echinocardium which were caught and their known habitat, the depth to which a heavily chained beam trawl disturbs the sea bed may be of the order of 10 to 20 cm.

All fish caught by the beam trawler were more badly damaged than those caught by the otter trawlers. This applies to all categories of damage and lengths of fish and it was particularly evident in plaice, but less so in soles.

The damage of the beam trawl catch could be due to either or both of two causes: to the action of the gear itself in disturbing fish from the sea bed, or to the presence of large quantities of invertebrates and debris in the cod-end. It was apparent that sole damage was greater in hauls when large quantities of shells were caught than in those when few were caught, as is also normal experience with otter trawls. It is therefore valid to conclude that a large proportion of the damage occurred in the cod-end and was caused by the bycatch and debris.

The presence of 'rotten' and dead fish in the catches has several possible explanations. They may have been fish remaining in the net from earlier hauls, but in this case it is hard to account for their advanced state of decomposition and numbers. It is also possible that they were fish which had been damaged by a trawl passing over them, and which had subsequently decomposed and been partially consumed by invertebrate scavengers before being recaught by another trawl. The third possibility is that they were fish rejected by trawlers after capture, and this is supported by the high proportion of 'rotten' small soles on ENNIE EN APPIE. The few large soles caught in this condition could be explained by chance rejection because the catch is washed down on deck with the scuppers open and occasionally large soles escape (this was seen to happen on ENNIE EN APPIE). Nearly all plaice and all dabs were rejected and would soon achieve a 'rotten' condition in the presence of efficient invertebrate scavengers such as Buccinum undatum (whelk) on the sea bed.

CONCLUSIONS

1 Fish captured by a heavily chained beam trawl are damaged by the quantity of benthos and debris caught in the cod-end.

2 There is no evidence that the selective action of the cod-end meshes is impaired or that fish which escape from the cod-end are extensively damaged.

3 The presence of dead and 'rotten' fish on the grounds is mainly due to rejection of small fish and unwanted species from the beam trawlers, and is not caused by the direct action of the trawl heads and tickler chains.

4 Large quantities of invertebrates are caught by a heavily chained beam trawl. The extent of damage to these animals depends on the quantity of debris caught with them.

This project has dealt with the effects on marine life by one beam trawler in a fleet of similar vessels operating in one area at one particular time. It is reasonable to suppose, however, that all the main conclusions will apply to any heavily chained beam trawl fishery.

ACKNOWLEDGEMENTS

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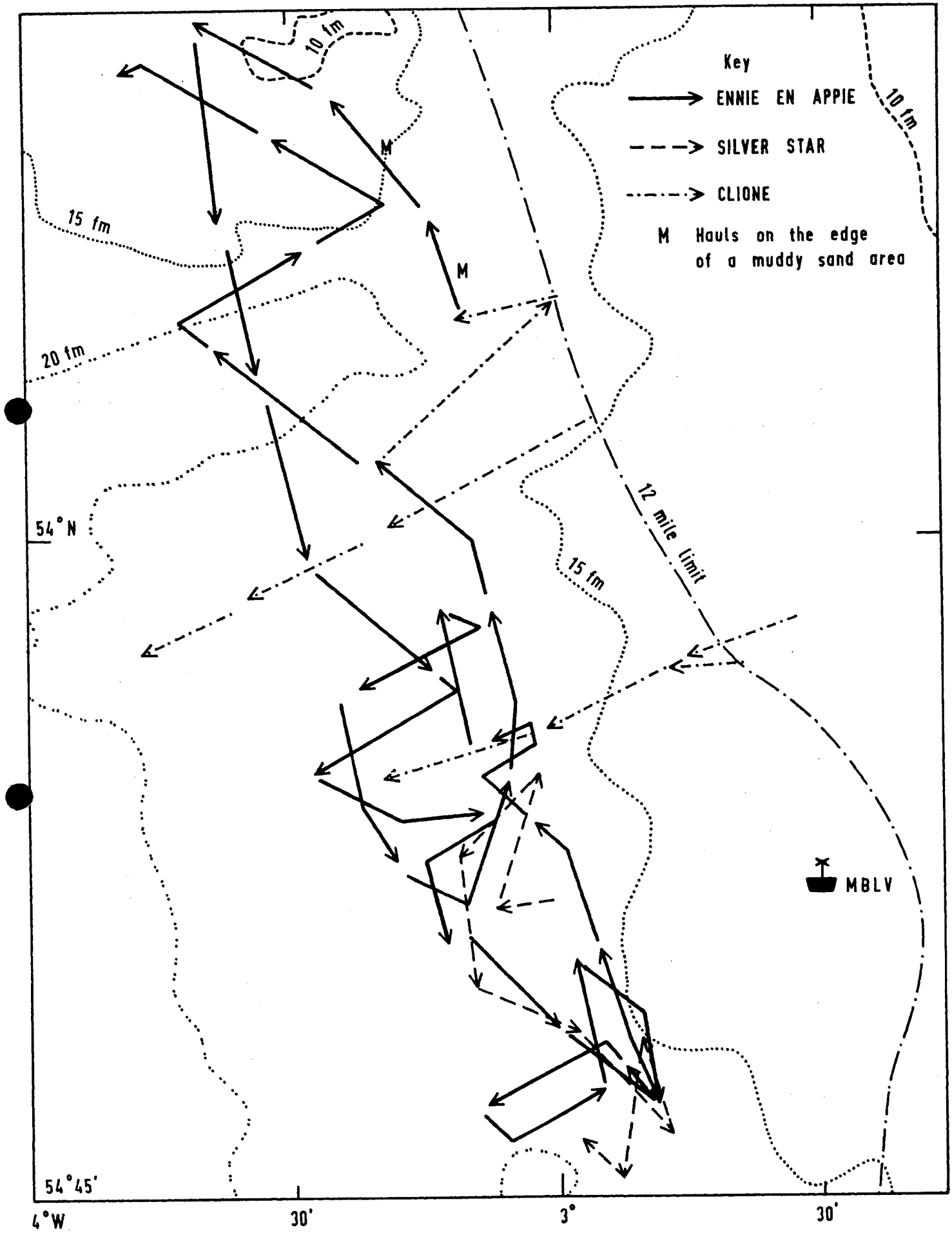

Fig.1 Trawl haul positions

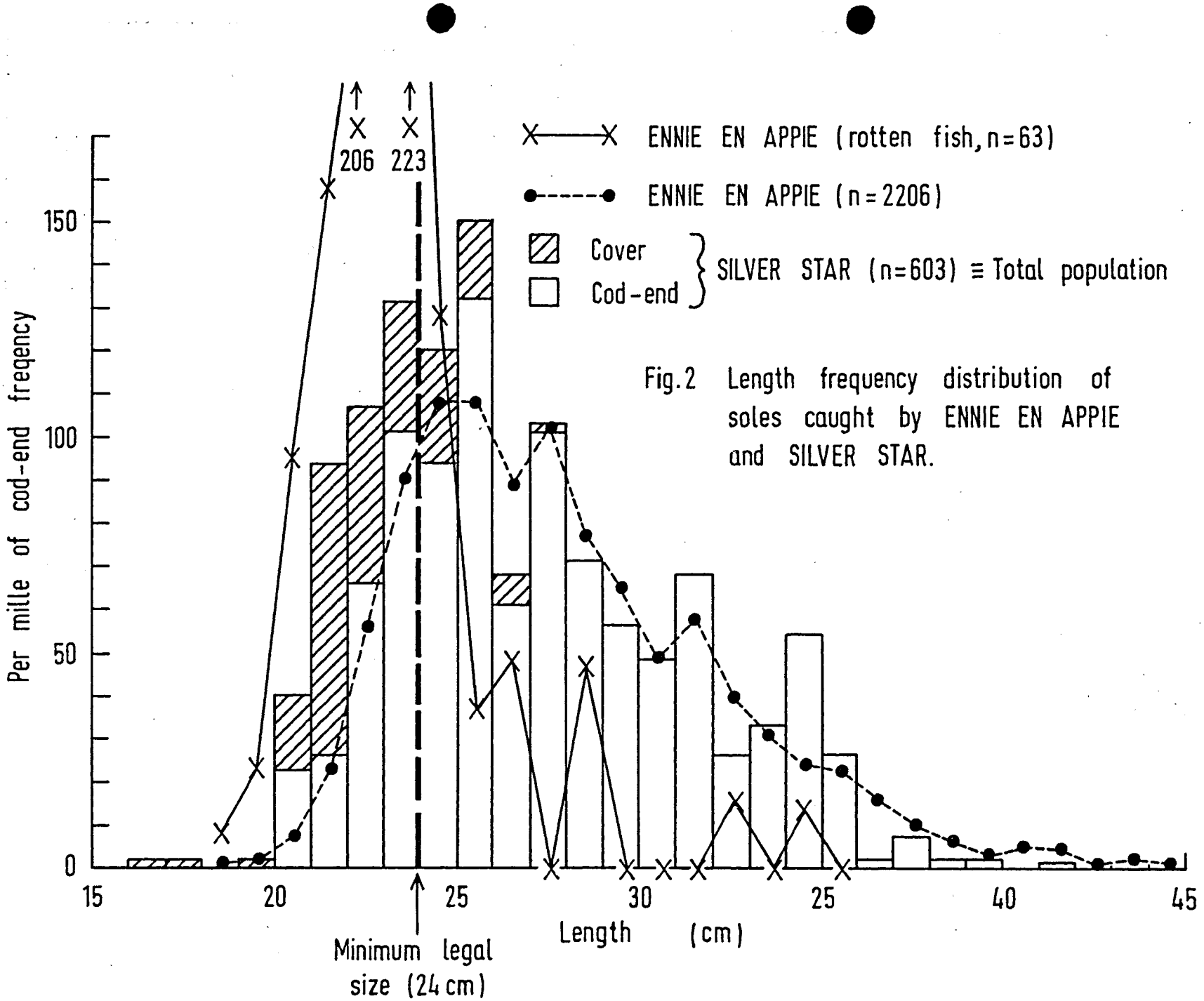

Fig. 2 Length frequency distribution of soles caught by ENNIE EN APPIE and SILVER STAR.

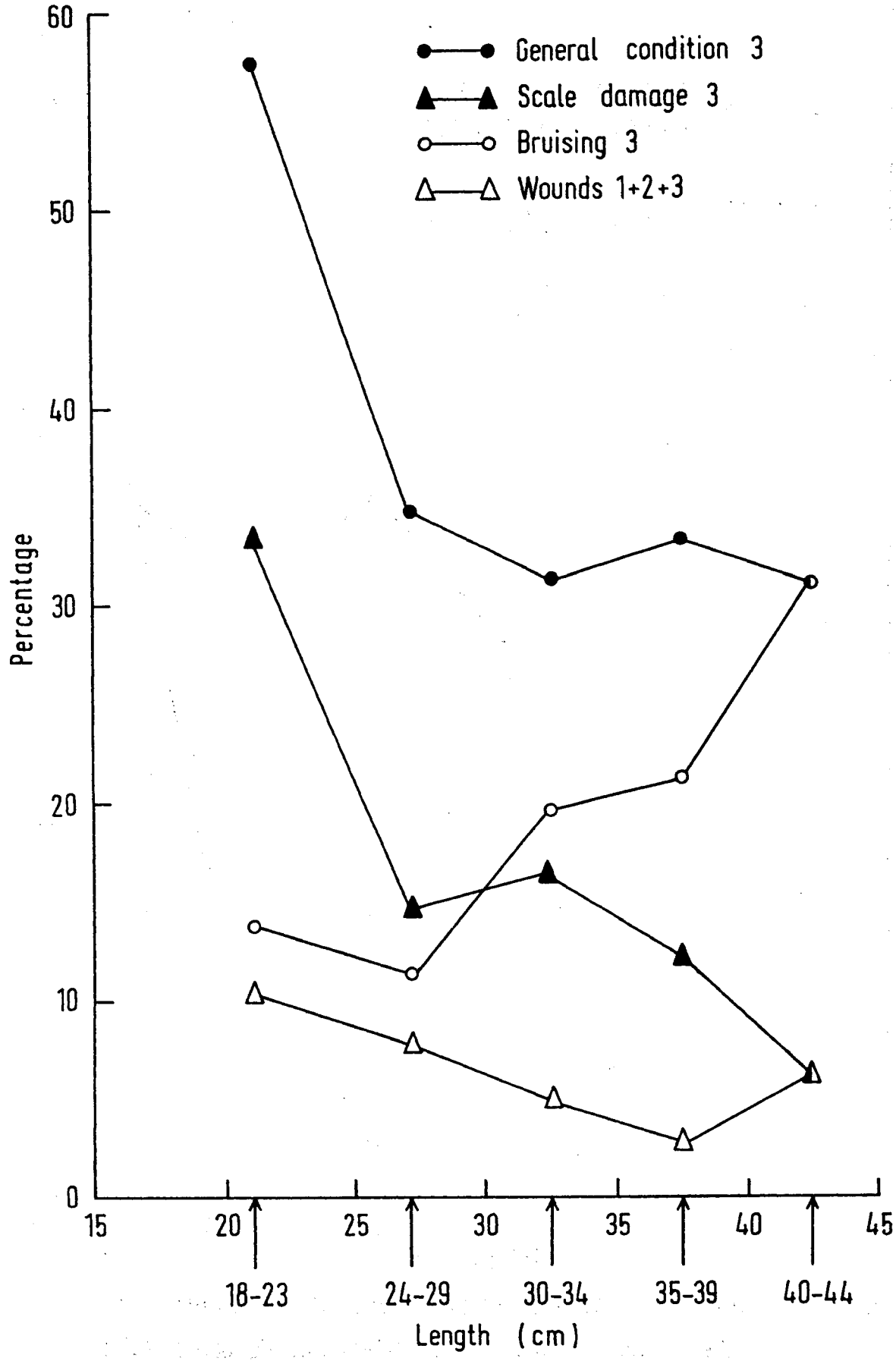

Fig. 3 Relationship between damage and length - ENNIE EN APPIE, soles

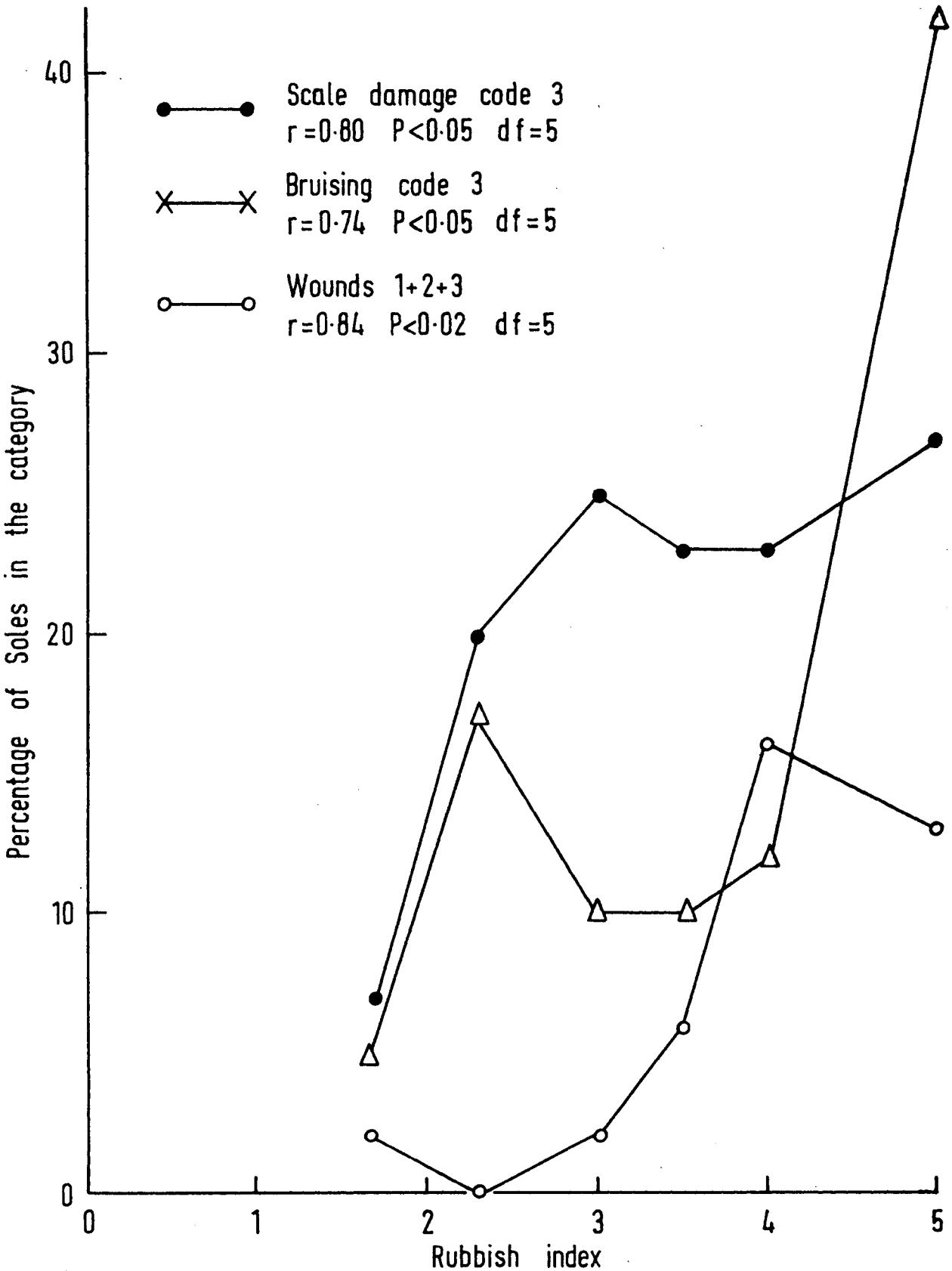

Fig. 4 Relationship between damage and the "rubbish index" i.e. the ratio volume of invertebrates + debris : volume of fish in the catch.

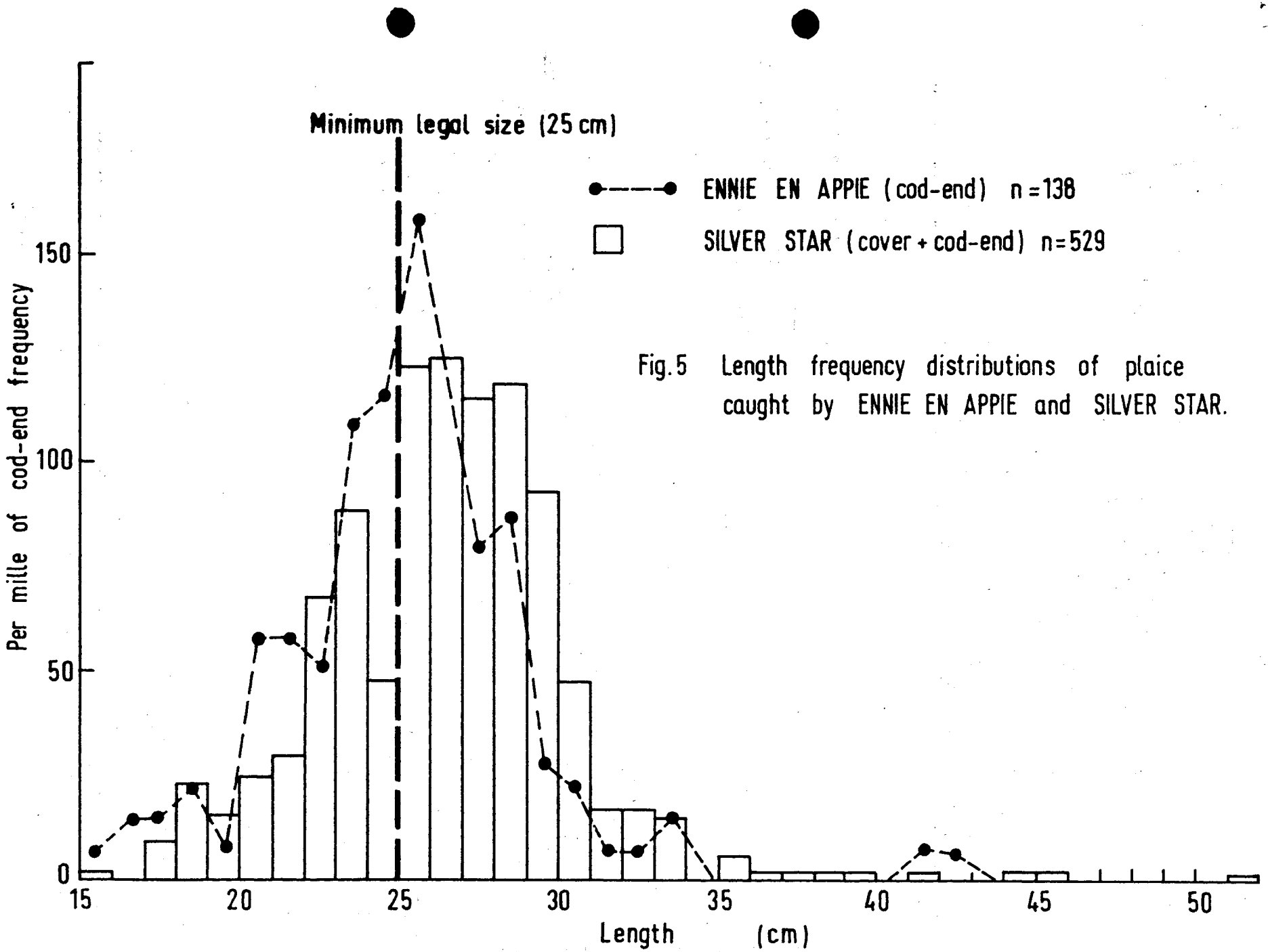

Fig. 5 Length frequency distributions of plaice caught by ENNIE EN APPIE and SILVER STAR.

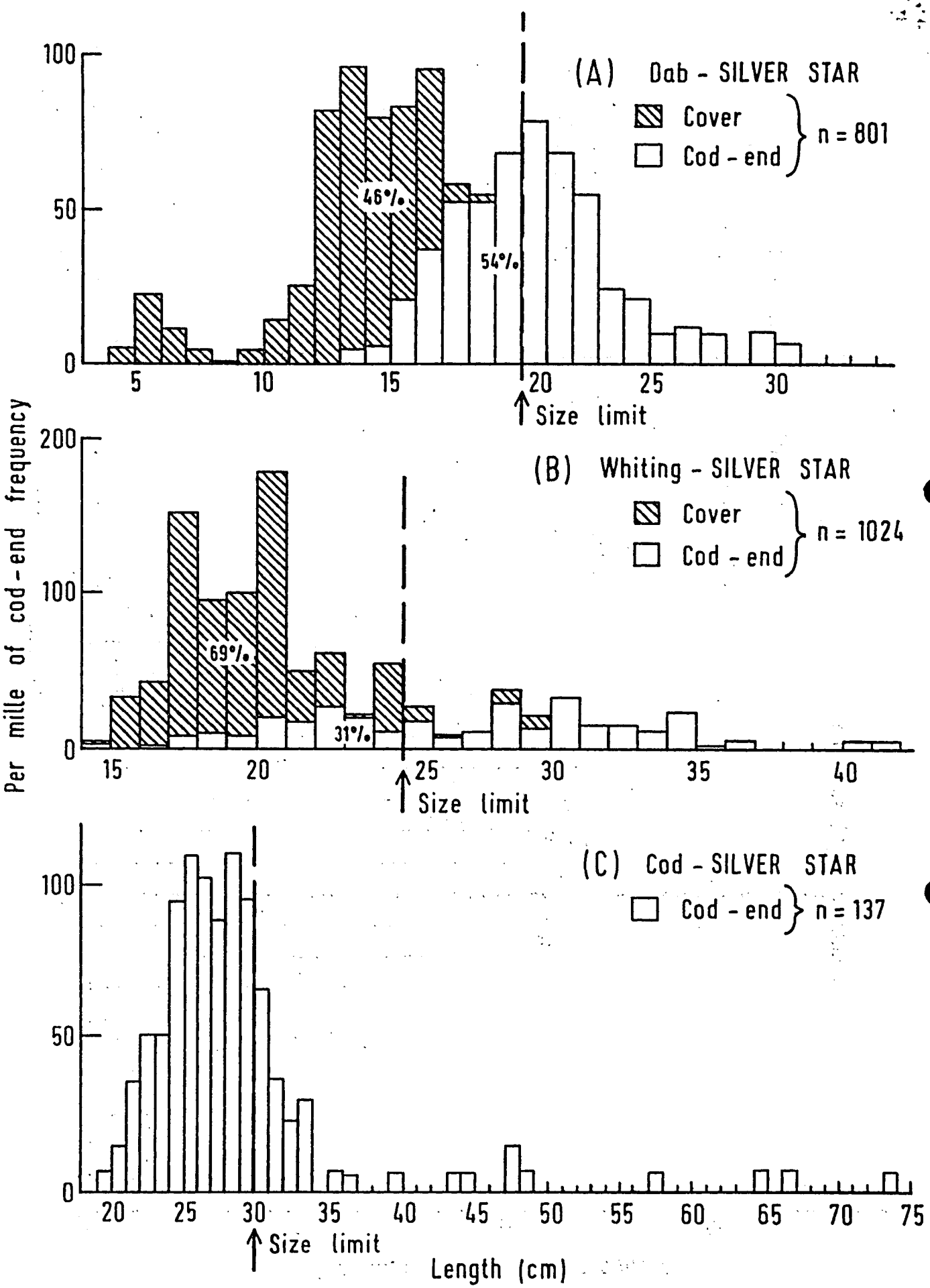

Fig. 6 Length frequency distributions of dab, whiting and cod caught by SILVER STAR