Table 1. The distribution of scallops at each age and the relationship between age and natural mortality (M)

Age	Number at each age, original data	Number at each age from curve in Fig. 1	Natural mortality coefficient M	Natural mortality rate %
3	11			
4	146			
5	441			
6	583	565		
7	453	480	0·164	15·1
8	339	402	0·178	16·3
9	303	332	0·187	17·1
10	304	270	0·207	18·7
11	219	213	0·238	21·2
12	195	164	0·263	23·1
13	136	123	0·281	24·5
14	92	88	0·335	28·5
15	54	61	0·367	30·7
16	34	38	0·475	37·8
17	20	20	0·642	47·4
18	8	8·4	0·868	58·0
19	2	2·7	1·136	67·9
20	2	–		

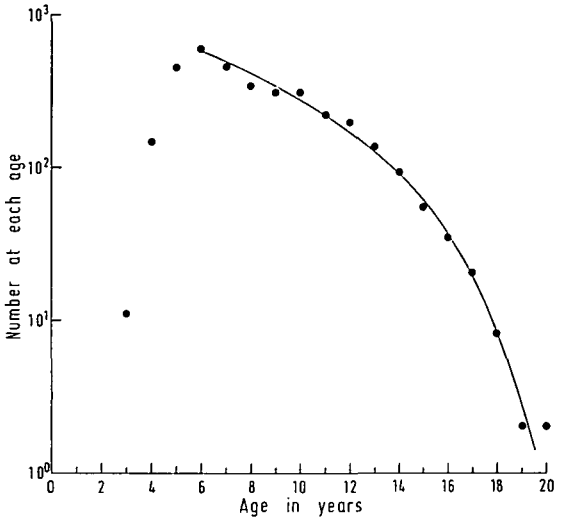

Figure 1. A plot of abundance of a year class of *Pecten maximus* against age, in an unexploited population. The curve was drawn by eye.

include a high proportion of deaths due indirectly to fishing. It is likely that dredges in common use cause a great deal of fatal damage to uncaught scallops (see Gruffydd, 1972), thus increasing natural mortality estimates beyond the true level.

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The effect of the door-to-door tickler chain on the catch-rate of plaice (*Pleuronectes platessa* L.) taken by an otter trawl

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Fishermen believe that the door-to-door tickler chains used with an otter trawl with short bridles will double the catch-rate of plaice, but we have not been able to find any published quantitative data to confirm this. The detailed trawling logs supplied by Skipper C. F. G. Page for the Lowestoft trawlers "Willa" in 1966–67 and "Cuttlefish" in 1969–72 provide haul-by-haul data which show the effect of the door-to-door tickler on the catch of plaice. These trawling logs have been described by Harden Jones, Scholes and Cheeseman (1969) and Scholes and Urquhart (1970). In the "remarks" column of the

Table 1. Some details of the trawl rigs used by Skipper Page on the trawlers "Willa" and "Cuttlefish"

Vessel	"Willa"	"Cuttlefish"
Fishing registration no..	Lt 43	Lt 65
Gross register tons	84	153
Registered length.....	25 m	28 m
bhp.....	323	360
Headrope	19·8 m	21·9 m
Backstrop	3 m	2·7 m
Bridles.....	9 m	12·8 m
Dan Leno	Stick	Butterfly and Scuttle
Footrope.....	29·2 m	32·3 m
Tickler's length and chain size		
Door	1×42·6 m, 13 mm	1×50·3 m, 16 mm
Dan Leno ...	1×28·6 m, 13 mm	–
	1×27·4 m, 13 mm	–
Midwing	–	1×18·6 m, 14 mm
Bosom.....	1×8·5 m, 14 mm	1×9·4 m, 14 mm

Note on scale models of the two rigs

MT "Willa". Assuming a normal door spread of 20 m, the midpoint of the door-to-door tickler chain would lie 8·8 and 3·6 m ahead of the midpoint of the footrope and headrope respectively.
MT "Cuttlefish". Assuming a normal door spread of 25 m, the midpoint of the door-to-door tickler chain would lie 10·3 and 4·5 m ahead of the midpoint of the footrope and headrope respectively.

trawling logs Skipper Page noted any damage to the gear and in the 5 years' data there were 15 tows in which the door-to-door tickler chain was found to be parted, or fouled, on hauling. In every other respect these hauls were normal without any other damage.

Particulars of the rigs worked by Skipper Page are given in Table 1, while Table 2 summarizes the details for the tows in which the door-to-door tickler was found to be fouled or parted on hauling. It has been assumed that the main effect on the catch was attributable to the door-to-door tickler and that the rest of the gear functioned normally. The catch of a tow in which the door-to-door tickler fouled or parted was compared with the catch of the immediately preceding tow and in all cases the two tows were made on the same ground and were of the same duration. Inspection of Table 3 shows that there was no difference in the catch-rate between the two tows in pairs 3, 9 and 13, but that in the other pairs the tow in which the tickler chain was parted or fouled had the lower catch-rate. Furthermore, there is a tendency for the catch-rate in the damaged and preceding tows to be high or low together, indicating factors common to both categories of tow which had a similar effect on the catch ($r = 0{\cdot}87$, $P < 0{\cdot}001$, d.f. = 13). It does therefore seem reasonable to accept the tows as valid pairs for statistical analysis as summarized in Table 3. A 't' test on the paired data (Snedecor and Cochran, 1967, p. 94) showed that the difference between the means was highly significant ($t = 4{\cdot}574^{***}$, d.f. = 14).

The mean percentage decrease in catch-rate in the tows in which the tickler chain was fouled or parted was 33%. The mean difference in catch-rate $\bar{D} = 13$ kg h^{-1}. Since

Table 2. Catch-rates of plaice in kg h^{-1} in tows in which the door-to-door tickler chain parted or was fouled and the preceding tow on the same ground. D = daylight, N = night, DN = sunset, ND = dawn tow

Fishing boat	Trip no.	Pair of tows no.	Date	Tow preceding kg h^{-1}	Day or night	Tow with tickler chain parted or fouled kg h^{-1}	Day or night	Fishing ground in the southern North Sea
"Willa"	29	1	18 Nov 1967	16·9	N	10·5	N	S. of Gt Silver Pit
	29	2	20 Nov 1967	7·6	N	2·5	N	Cromer Knoll
	29	3	21 Nov 1967	10·5	DN	10·5	N	Cromer Knoll
"Cuttlefish"	1	4	8 Sept 1969	61·0	ND	25·4	D	Botney Gut
	1	5	13 Sept 1969	27·7	D	11·5	D	S. of Gt Silver Pit
	2	6	2 Sept 1969	74·0	DN	50·8	N	S. of Gt Silver Pit
	2	7	22 Sept 1969	57·7	D	50·8	D	S. of Gt Silver Pit
	2	8	23 Sept 1969	76·2	N	50·8	N	Markhams Hole
	18	9	3 Jun 1970	31·7	D	31·7	D	W. side of Markhams Hole
	22	10	22 Jul 1970	31·7	D	20·9	D	Indefatigable Bank
	25	11	1 Sept 1970	50·8	D	25·4	D	Elbow Spit
	31	12	23 Nov 1970	19·0	ND	12·7	D	Smith's Knoll Bank
	39	13	18 Apr 1971	41·9	D	41·9	D	Rising Ground
	49	14	30 Aug 1971	46·3	DN	25·4	N	S. side of Gt Silver Pit
	58	15	17 Aug 1972	38·1	D	25·4	D	S. side of Gt Silver Pit

Table 3. Analysis of plaice catch in kg h^{-1} in paired tows

Pair no.	Preceding tow, X_1	Tow with door tickler parted or fouled X_2	Difference $D=X_1-X_2$	Percentage decrease in catch-rate
1	16·9	10·5	6·4	37
2	7·6	2·5	5·1	67
3	10·5	10·5	0·0	0
4	61·0	25·4	35·6	58
5	27·7	11·5	16·2	58
6	74·0	50·8	23·2	31
7	57·7	50·8	6·9	11
8	76·2	50·8	25·4	33
9	31·7	31·7	0·0	0
10	31·7	20·9	10·8	34
11	50·8	25·4	25·4	50
12	19·0	12·7	6·3	33
13	41·9	41·9	0·0	0
14	46·3	25·4	20·9	45
15	38·1	25·4	12·7	33
Mean	39·4	26·4	12·9	32·9

$$t_{0\cdot05}\, S_{\bar{D}} = (2\cdot145)\,(2\cdot84) = 6,$$

then at the 95% confidence level $\bar{D} = 13 \pm 6$, and the expected decrease in catch-rate would lie between 7 and 19 kg h^{-1}, corresponding to a reduction of 18 to 48% of a normal haul. A mean reduction in catch of 33% (from 100 kg h^{-1} to 67 kg $^{-}h^{1}$) corresponds to an increase in catch of 49%. But the observed reduction in catch after the parting of the tickler chain will underestimate its contribution to the efficiency of the gear, because the raw data give no indication as to whether the chain parted early or late in a particular tow. From the size of the catch it would not be unreasonable to suppose that the tickler chain parted late in the tows included in the paired hauls 3, 7, 9 and 13, and early in the tows in pairs 2, 4, 5, 11 and 14. The mean reduction in catch in the latter 5 pairs was 56%, suggesting that the door-to-door tickler would increase the catch by about 127% (just over ×2). Another approximation to the true effect of the tickler chain would be to assume that in the 15 tows it parted on average halfway through a tow and that its full effect would correspond to a reduction in catch of 66%, equivalent to an increase of 194% (nearly ×3). This suggests that the door-to-door tickler would increase the catch-rate of plaice by a factor of 2 to 3 and that the fishermen's estimate of its effectiveness is probably correct.

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