A Comparison of Catch Between Research and Commercial Vessels During a Trawl Survey of Hecate Strait, May 30 - June 13, 1996

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A COMPARISON OF CATCH BETWEEN RESEARCH AND COMMERCIAL VESSELS DURING A TRAWL SURVEY OF HECATE STRAIT, MAY 30 - JUNE 13, 1996

by

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ABSTRACT

Fargo, J., and G. D. Workman. 1997. A comparision of catch between research and commercial vessels during a trawl survey of Hecate Strait, May 30 - June 13, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2425: 41 p.

We analysed replicate haul data from a bottom trawl survey conducted in Hecate Strait. The hauls made by the research vessel were replicated by a trawler using commercial trawl net with a 6 inch mesh. The purpose of this work was to examine the validity of the research vessel CPUE data for stock assessment work and to evaluate the effect of the mesh regulation imposed by the DFO in this area in 1995. We found no significant difference in the replicate CPUE data between the two vessels for Pacific cod *(Gadus macrocephalus)*, Dover sole *(Microstomus pacificus)*, English sole *(Pleuronectes vetulus)* and Rock sole *(Plueronectes bilineata)*. However, length composition data did differ between the two vessels due to the different mesh sizes in the nets used. Mean lengths for the four commercial species were significantly greater for the commercial vessel using 6 inch mesh than the research vessel using 3.5 inch mesh. Catch rates for juvenile flatfish for the commercial vessel were $\leq$ 10% of those for the research vessel. Catch-rates for larger fish were 1.5 - 2 times greater for the commercial vessel than the research, possibly due to the greater herding effect for the commercial gear. The length-specific selectivity ratio for the commercial vessel approached 1 at a length corresponding to the recommended minimum size limit for all of the flatfish species. The change in size selectivity for commercial flatfish species due to the larger mesh size must be accommodated in catch-age analysis used for stock assessment of these species. The differential catch rates for larger fish between the two vessels should be evaluated on the next survey.

RÉSUMÉ

Fargo, J., and G. D. Workman. 1997. A comparision of catch between research and commercial vessels during a trawl survey of Hecate Strait, May 30 - June 13, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2425: 41 p.

Nous avons analysé les données obtenues par traits répétés pendant un relevé au chalut dans le détroit d'Hécate. Les traits effectués par le navire de recherche ont été répétés par un chalutier armé pour le chalutage commercial avec un filet à maillage de 6 pouces. La mission avait pour objet de vérifier la validité des données CPUE obtenues par le bâtiment de recherche pour le travail d'évaluation des stocks, et de déterminer l'effet de la réglementation sur le maillage imposée en 1995 par le MPO dans cette région. Nous n'avons pas observé de différence significative dans les données CPUE obtenues en parallèle par les deux bateaux pour la morue pacifique (*Gadus macrocephalus*), la limande-sole (*Microstomus pacificus*), le carlottin anglais (*Pleuronectes vetulus*) et la sole pacifique (*Pleuronectes bilineata*). Les données sur la composition par longueur différaient toutefois entre les deux bateaux à cause des maillages employés. Les longueurs moyennes pour les quatre espèces commerciales étaient nettement plus grandes avec le chalutier commercial utilisant un maillage de 6 pouces qu'avec le bateau de recherche qui employait un filet à maillage de 3,5 pouces. Les taux de capture des poissons plats juvéniles étaient # 10 % de ceux du bâtiment de recherche. Les taux de capture des poissons plus gros étaient 1,5 à 2 fois supérieurs avec le chalutier, ce qui peut être dû à l'effet de regroupement plus efficace avec le gréement commercial. Le rapport de sélectivité spécifique à la longueur dans le filet commercial approchait de 1 à une longueur correspondant à la limite minimale de taille recommandée pour tous les poissons plats. Le changement de la sélectivité par taille des espèces commerciales de poissons plats doit être pris en compte dans l'analyse de l'âge à la capture qui sert à l'évaluation des stocks de ces espèces. La différence entre les deux bateaux dans le taux de capture des poissons de grande taille doit être évaluée lors du prochain relevé.

INTRODUCTION

Between May 30 and June 13, 1996 we conducted a bottom trawl survey in Hecate Strait using the research vessel W.E. RICKER. This was the eighth survey in a biannual series (Workman et al. 1997). Information from the surveys is used in stock assessment work at the Pacific Biological Station. On the 1996 survey a commercial fishing vessel was chartered to replicate hauls made by the research vessel. This was done to compare the catch-rate and biological data for a typical commercial vessel with that for the research vessel to assess: 1) how appropriate the research vessel CPUE indices are for stock assessment work, and 2) the length-specific selectivity of commercial groundfish species under the current minimum mesh regulation in the Strait. This report presents the results of analyses comparing catch-rate and biological data between the research vessel, W.E. RICKER, and a chartered commercial trawler, the STEADFAST.

METHODS

VESSELS AND GEAR

Specifications for the two vessels and their fishing gear have been reported by Workman et al. (1997). Briefly, the R/V W.E. RICKER (WER) is a 2500 hp, 57.3 m steel stern trawler which used a Yankee 36 trawl of heavy construction with 8.75 cm (3.5 in) mesh throughout and a 2.5 cm codend liner. The F/V STEADFAST (STD) is a 380 hp, 20 m steel stern trawler that was chartered to replicate sites occupied by WER during the first half of the survey. The net used by STD was a Safari 5 with 15.2 cm (6 in) mesh throughout. This net is typical of the commercial fishery in Hecate Strait.

The systematic stratified design for the survey has been described in Westrheim et al. (1984) and Fargo et al. (1984). The haul locations are approximately the same on every survey conducted. The survey covers the entire Strait and replicate hauls were done throughout the Strait on the 1996 survey. Fishing occurred during daylight hours only. Towing time was 30 minutes, measured from the time the warp drums were locked to the time net retrieval began. For replicate hauls STD waited until WER had locked its warps and then set off the port or starboard stern quarters, usually within 500 m of WER.

CATCH DATA

To facilitate comparison between vessels we standardized the data for differences in towing time, net configuration and net mesh size. First we corrected for differences in the size of the area swept by the two nets, using measurements of various fishing components assuming that the effective area swept by a trawl net was

best represented by the door spread (Nagtegaal 1986). We estimated the door spread for each net using the method of Carrothers (1980). Wingspread, sweep length and bridle length were used for these calculations. Wingspread for the Yankee 36 (WER), measured directly during the survey, ranged from 10 m to 12 m. For the Safari net rigged with Thyboron 96 doors we used a value of 10.75 m for the wingspread determined from flume tank studies conducted on the Atlantic coast (Jon Johannesson, Cantrawl Pacific Ltd., pers. comm.). We also used two alternate methods of estimating the wingspread: 1) dividing the length of the headline in half; and 2) dividing the length of the headline plus the footrope by 4 (Table 1) (Hand et al. 1995, Yamanaka et al.1996). The area swept by the doors was adjusted for the curvature of the ground warp using catenary parameters determined in previous work (Yamanaka et al. 1996). We assumed that the herding effect of the sweeplines was similar for both vessels. The final estimate of door spread for STD was 14% greater than that for WER and we multiplied the catches for STD by 0.86 to correct for this difference. We corrected for minor differences in towing time by calculating the catch weight for one hour of towing (corrected CPUE) for each vessel.

To correct for differences in net mesh size we used the length frequency data and corresponding length-weight relationship to estimate the catch of fish greater than 34 cm (the size flatfish are graded for at sea by the fishermen for the processing plants and approximately equivalent to the size fully selected for the STD net). For the few instances where length data were not collected we used the mean weight of fish greater than 34 cm for the 48 replicate hauls for a given species and vessel.

We tested for differences in CPUE between the two vessels using the Fisher test and the non-parametric Mann-Whitney signed rank test. We used the Fisher randomization test (Manly 1991) to test for differences in mean corrected CPUE between vessels. Both tests are appropriate for data that are not normally distributed as is typical of CPUE data. The Fisher test re-samples the differences from the replicate CPUE data to produce a distribution of differences from which the probability level for the mean of the differences is determined. The Mann-Whitney test gives a rank sum statistic for the two sets of CPUE data that was used to test for differences between the two sets of data. We removed replicates where CPUE was zero for both vessels prior to statistical testing.

We estimated the length-specific retention ratios for STD compared to WER for Pacific cod *(Gadus macrocephalus)*, Dover sole *(Microstomus pacificus)*, English sole *(Pleuronectes vetulus)* and Rock sole *(Pleuronectes bilineata)* using the following procedure. For the flatfish species, we calculated the numbers caught per hour for 3 cm length intervals and divided these values for STD by those for WER. The resulting ratio then reflects the length-specific retention rates for the flatfish species for STD compared to WER. We used the same procedure for Pacific cod but grouped the data by 5 cm length intervals.

BIOLOGICAL DATA

We compared the numbers caught and the size composition data between the two vessels for four important commercial species in the region: Pacific cod, rock sole, Dover sole and English sole. Random sub-samples were collected from large catches of individual species. All fish were sampled from smaller catches (<500 kg) We extrapolated from sub-samples to total numbers caught using the ratio of total weight caught, the numbers sub-sampled and the weight of the sub-sample.

RESULTS

CATCH DATA

The two vessels completed 48 replicate hauls on the survey (Figure 1). Both total catch and species composition for replicate hauls were similar between the two vessels (Table 2). Catches of flatfish and roundfish were higher for WER while catches of rockfish and selachii were higher for STD (Figure 2). Rockfish and selachii are not primary targets of the survey.

The uncorrected catch for the four species examined is presented by vessel in Figure 3. The uncorrected catch for Pacific cod and rock sole was nearly the same between the two vessels while that for Dover and English soles was higher for WER (Table 3, Figure 3). The corrected catch for Pacific cod, rock sole and Dover sole was higher for STD while the corrected catch for English sole was slightly higher for WER (Table 3, Figure 3). CPUE data by replicate haul, species and vessel are presented in Table 4. Statistics for corrected and uncorrected CPUE by species for each vessel are presented in Tables 5-6. The uncorrected mean CPUE for English sole and Dover sole was higher for WER while the uncorrected mean for Pacific cod was higher for STD (Figure 4) and the uncorrected mean for rock sole was nearly the same between the two vessels. Correcting for door spread reduced the species mean CPUEs of STD because the net used by STD had a larger swept area than that of WER. However, correcting for mesh size had the most significant effect on the final estimates of the catches and mean CPUEs. This resulted in a decrease in catch and mean CPUEs calculated for WER. The mean corrected CPUE for Pacific cod, rock sole and Dover sole was higher for STD while that for English sole was nearly the same for both vessels (Figure 4). The 90% confidence intervals of the means for all four species overlapped between the two vessels.

We used non-parametric statistics to test the CPUE data for differences between the two vessels. Plots of the corrected CPUE data (Figure 5) suggest that there was little difference in CPUE in replicates between the two vessels, although the highest CPUEs for both vessels did not necessarily occur on the same haul. There

was no significant difference in the corrected CPUE data among replicates for the two vessels for any of the species examined (Fisher test, Mann-Whitney test).

BIOLOGICAL DATA

Summary statistics for the length data for each vessel are presented in Tables 7 and 8. The mean length of fish sampled for all four species was significantly greater for STD for all four species (t test, $p<0.0001$). There were significant differences in the species length distributions between the two vessels as well (Mann-Whitney test, $P<0.0001$) (Figures 6-9). Rock sole caught by WER showed modes at 21 cm and 33 cm. The 21 cm mode is absent in length frequency distributions for STD. For Pacific cod, a mode at 28 cm is prominent in the distribution for WER but is not in the distribution for STD. Dover sole caught by WER showed a strong mode at 30 cm while fish caught by STD showed modes at 33 cm and 43 cm. English sole caught by WER showed a mode at 26 cm compared to a mode at 33 cm for fish caught by STD.

Cumulative frequency plots of numbers-at-length for the four species are presented by vessel in Figure 10. Approximately fifty percent of the Pacific cod caught by both vessels were less than 50 cm. However, 29% of the Pacific cod caught by WER were less than 40 cm while only 13% caught by STD were less than 40 cm. For rock sole 53% of the fish caught by WER were less than 25 cm while only 4% of those caught by STD were under 25 cm. For English sole 47% of the fish caught by WER were less than 25 cm while only 11% of those caught by STD were under 25 cm. For Dover sole 65% of the fish caught by WER were less than 30 cm while only 7% of the fish caught by STD were under 30 cm.

The length-specific retention ratios for STD / WER are presented by species in Figure 11. The lines in the plots indicate the lowess smoothed trend to these data. Overall STD caught fewer smaller and more larger fish than WER for all four species. However, the small sample sizes at the high end of the length range contributed to high variability of the ratio in all cases. The STD retention ratio for Pacific cod ranged from 0.2 for fish of 26 cm to between 1-2.3 for fish larger than 50 cm. The retention ratio for Pacific cod approached 1 at a size of 35 cm. The retention ratio for rock sole ranged from 0.0 for fish smaller than 20 cm to 1.2-2.0 for fish larger than 35 cm. The retention ratio for rock sole approached 1 at a size of 33 cm. The retention ratio for Dover sole ranged from 0.0 for fish smaller than 30 cm to between 2.0-8.4 for fish larger than 40 cm. The retention ratio for Dover sole approached 1 at a size of about 38 cm. The retention ratio for English sole ranged from 0.0 for fish smaller than 20 cm to 1-1.3 for fish larger than 36 cm. The retention ratio approached 1 at a size of about 36 cm.

DISCUSSION

Overall the species catch composition between the two vessels did not differ appreciably. In fact, the catch of flatfish was nearly identical. The differences in the catch of roundfish between the two vessels were due mainly to small non-commercial species that were caught by WER and not by STD. STD caught more rockfish than WER, however this is to be expected. The Safari 5 (STD) is a high lift box trawl, which is better for catching off-bottom species like rockfish while the Yankee 36 (WER) is a flat trawl with a groundline composed of 152 mm (6 inch) rubber discs designed to catch all sizes of flatfish. There was no measurable difference in CPUE between the two vessels after correcting for differences in the fishing gear used. This is despite the fact that depth and location differed slightly between the two vessels for the replicate hauls. However, the highest CPUEs for all species did not occur on the same haul. This is probably due to the fact that the habitat in the Strait is very diverse and the distributions for individual species are not homogeneous (Fargo and Tyler 1991).

There were significant differences in species size composition between the two vessels due to the different mesh size in the two nets. WER caught more small non-commercial species and juveniles of commercial species than STD did. STD caught greater numbers of large fish than WER. To be able to relate this to the fishing gear used we require more detailed knowledge of the gear avoidance behaviour of these species. It is well known, however, that longer sweep lines have a greater herding effect on flatfish species (Harden Jones et al. 1977). Underwater camera work in the Gulf of Alaska and in Hecate Strait indicates that flatfish swim continuously in front of approaching trawl gear until they are exhausted and are either captured or the groundline and net passes over them. The largest individuals are the strongest swimmers. The longer sweep lines of STD may have contributed to a greater herding effect forcing the larger individuals to swim ahead of the net for a longer period, making them more susceptible to exhaustion and capture. More work on fish avoidance behaviour and fishing gear performance is necessary to confirm this.

If we assume that WER caught 100% of the juvenile flatfish available then the net used by STD was 100% selective for rock sole at 33 cm, English sole at 38 cm and Dover sole at 36 cm. Length at 50% maturity has been used as guidance for setting minimum size regulations for flatfish and other groundfish species. This corresponds to a size/age where yield per recruit is maximized for moderate-fast growing species. Length of 50% maturity is 34.1 cm for rock sole, 35.5 cm for English sole and 38.1 cm for Dover sole. Thus, there is evidence from this work that 6 inch mesh size significantly lowers the discard rate for juvenile sole (ages 1-3) and Pacific cod (ages 1,2). In addition, the bycatch of small, non-commercial species such as Pacific sanddab *(Citharichthys sordidus)*, C-O sole *(Pleuronichthys coenosus)*, curlfin sole *(Pleuronichthys decurrens)*, sablefish *(Anaplopoma fimbria)* and others was also reduced.

The selectivity ratios determined in this study can be used to adjust the size and age data for the flatfish species to account changes in fishery selectivity after the mesh size regulation imposed in 1995. This will result in more accurate population estimates from catch-age analysis used for stock assessment of these species.

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Table 1. Net Dimensions and calculated door spread (Carrothers 1980). Measured wingspread values were used, but two alternate methods of estimating wingspread were evaluated to provide some data for comparison. Values selected to standardize the data are in bold.

Net	Headline length (ft)	Sweep Length (ft)	Bridle length (ft)	Wingspread (ft)	Method for estimating wingspread	Doorspread (ft)
Yankee 36	60	60	60	30	HL/2[1]	97
Yankee 36	60	60	60	35	HLFR/4[2]	121
Yankee 36	**60**	**60**	**60**	**39**	**M-FS3300[3]**	**126**
Safari 5	72	90	120	36	HL/2[1]	151
Safari 5	72	90	120	41	HLFR/4[2]	185
Safari 5	**72**	**90**	**120**	**35**	**M-FT[4]**	**145**

[1] HL/2 Headline length divided by 2
[2] HLFR/4 = Headline length plus Footrope length divided by 4
[3] M-FS3300 = Mean net opening measure with a FS3300 headline net sounder
[4] M-FT = Measured in a flume tank, Jon Johannesson at Can-Trawl Pacific Pers. Comm.

Table 2. Catch by species for 48 replicate hauls made by the R/V W.E. RICKER (WER) and the F/V STEADFAST (STD) on the Hecate Strait groundfish survey, May 29 - June 14, 1996.

	Catch (kg)		% of Total catch	
Species	WER	STD	WER	STD
Flatfish				
Arrowtooth flounder	4878	5138	15.9	20.7
Petrale sole	29	89	0.1	0.4
Rex sole	2186	1098	7.1	4.4
Flathead sole	229	148	0.7	0.6
Pacific halibut	1911	1616	6.2	6.5
Butter sole	166	80	0.5	0.3
Rock sole	1618	1668	5.3	6.7
Slender sole	22	6	0.1	0.0
Dover sole	955	461	3.1	1.9
English sole	4134	2861	13.4	11.5
Starry flounder	16	4	0.1	0.0
Curlfin sole	12	17	0	0.1
Sand sole	91	144	0.3	0.6
Pacific sanddab	845	221	2.7	0.9
Total	17092	13551		
Roundfish				
Pacific herring	1775	0	5.8	0
Chinook salmon	0	3	0.0	0
Eulachon	48	0	0.2	0
Pacific cod	1740	1706	5.7	6.9
Pacific hake	1	0	0.0	0
Pacific tomcod	98	0	0.3	0
Walleye pollock	2739	209	8.9	0.8
Eelpouts	2	0	0.0	0
Wolfeel	10	2	0.0	0
Sandlance	51	0	0.2	0
Sablefish	1185	416	3.9	1.7
Greenlings	4	0	0.0	0

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	Catch (kg)		% of Total catch	
Species	**WER**	**STD**	**WER**	**STD**
Roundfish (Cont'd)				
Lingcod	207	268	0.7	1.1
Sculpins	6	7	0	0
Poachers	3	0	0	0
Total	8069	2611		
Rockfish				
Redbanded rockfish	20	109	0.1	0.4
Silvergray rockfish	2	16	0	0.1
Yellowtail rockfish	91	211	0.3	0.9
Quillback rockfish	40	30	0.1	0.1
Bocaccio	25	23	0.1	0.1
Canary rockfish	2	6	0.0	0.0
Redstripe rockfish	1	0	0.0	0.0
Yelloweye rockfish	10	5	0.0	0.0
Pygmy rockfish	5	0	0.0	0.0
Total	196	400		
Selachii				
Spiny dogfish	1112	900	3.6	3.6
Skates	675	1406	2.2	5.7
Spotted ratfish	3797	5909	12.4	23.8
Total	5584	8215		
Grand Total	**30941**	**24777**	**100.0**	**100.0**

Table 3. Actual (uncorrected) catch (kg) and catch corrected for differences in fishing gear used by the F/V Steadfast and the R/V WE Ricker .

	Steadfast		Percent	WE Ricker		Percent
	uncorrected	corrected	Change	uncorrected	corrected	Change
Pacific cod	1706	1504	-12	1740	1344	-23
Rock sole	1668	1020	-39	1618	816	-50
Dover sole	461	328	-29	955	197	-79
English sole	2861	1070	-63	4134	1085	-74

Table 4. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	Uncorrected CPUE (kg/h) WER	Correctted CPUE (kh/h) STD	Correctted CPUE (kh/h) WER
1	Pacific Cod	4.0	6.0	3.7	5.8
2	Pacific Cod	442.0	198.0	379.6	198.0
3	Pacific Cod	13.6	52.0	1.1	13.8
4	Pacific Cod	0.0	1.0	5.4	1.0
5	Pacific Cod	0.0	0.0	0.0	0.0
6	Pacific Cod	0.0	0.0	0.0	0.0
7	Pacific Cod	75.0	0.0	59.5	0.0
8	Pacific Cod	8.0	1.0	6.4	1.0
9	Pacific Cod	0.0	1.0	0.0	1.0
10	Pacific Cod	3.0	4.0	0.0	0.0
11	Pacific Cod	0.0	0.0	0.0	0.0
12	Pacific Cod	22.5	0.0	19.6	0.0
13	Pacific Cod	3.4	0.0	3.0	0.0
14	Pacific Cod	0.0	12.0	0.0	9.9
15	Pacific Cod	45.0	6.0	38.0	5.1
16	Pacific Cod	0.0	0.0	0.0	0.0
17	Pacific Cod	23.3	26.0	22.5	26.9
18	Pacific Cod	10.0	10.0	9.7	9.6
19	Pacific Cod	8.3	0.0	9.4	0.0
20	Pacific Cod	92.7	46.0	85.0	42.4
21	Pacific Cod	54.9	238.0	53.1	236.0
22	Pacific Cod	0.0	36.0	49.2	33.5
23	Pacific Cod	0.0	0.0	0.0	0.0
24	Pacific Cod	0.0	0.0	0.0	0.0
25	Pacific Cod	2.0	2.0	0.0	0.0
26	Pacific Cod	176.0	88.0	150.5	85.2
27	Pacific Cod	110.3	28.0	115.1	26.9
28	Pacific Cod	117.6	64.0	116.8	57.6
29	Pacific Cod	28.0	30.0	25.5	32.1
30	Pacific Cod	68.0	6.0	62.2	0.0
31	Pacific Cod	1.7	0.0	0.0	0.0
32	Pacific Cod	0.0	0.0	0.0	0.0
33	Pacific Cod	0.0	0.0	0.0	0.0
34	Pacific Cod	0.0	0.0	0.0	0.0
35	Pacific Cod	1.7	0.0	0.0	0.0
36	Pacific Cod	0.0	1.0	0.0	1.0

Table 4 - Con't. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	Uncorrected CPUE (kg/h) WER	Corrected CPUE (kh/h) STD	Corrected CPUE (kh/h) WER
37	Pacific Cod	352.0	1278.0	306.2	1226.9
38	Pacific Cod	252.0	48.0	219.2	47.7
39	Pacific Cod	82.8	90.0	69.7	88.5
40	Pacific Cod	24.8	88.0	21.4	87.0
41	Pacific Cod	732.0	202.0	630.5	202.0
42	Pacific Cod	14.1	2.0	11.1	1.9
43	Pacific Cod	10.0	82.0	10.4	82.0
44	Pacific Cod	237.8	38.0	216.7	38.0
45	Pacific Cod	62.0	30.0	56.3	28.8
46	Pacific Cod	226.3	94.0	210.8	90.2
47	Pacific Cod	48.9	0.0	41.0	0.0
48	Pacific Cod	0.0	8.0	0.0	7.7
1	Rock sole	0.0	0.0	0.0	0.0
2	Rock sole	0.0	0.0	0.0	0.0
3	Rock sole	0.0	24.0	0.0	8.6
4	Rock sole	856.0	1.0	655.1	0.5
5	Rock sole	33.8	0.0	20.9	0.0
6	Rock sole	1.7	0.0	1.3	0.0
7	Rock sole	7.5	1.0	3.9	0.5
8	Rock sole	110.0	34.0	69.9	14.3
9	Rock sole	66.9	74.0	56.8	29.6
10	Rock sole	123.0	120.0	96.8	84.6
11	Rock sole	8.0	4.0	4.8	3.7
12	Rock sole	4.5	0.0	3.0	0.0
13	Rock sole	0.0	0.0	0.0	0.0
14	Rock sole	0.0	0.0	0.0	0.0
15	Rock sole	5.0	6.0	2.5	3.2
16	Rock sole	1.0	0.0	0.0	0.0
17	Rock sole	0.0	0.0	0.0	0.0
18	Rock sole	0.0	0.0	0.0	0.0
19	Rock sole	0.0	0.0	0.0	0.0
20	Rock sole	0.0	0.0	0.0	0.0
21	Rock sole	0.0	1.0	0.0	0.5
22	Rock sole	0.0	0.0	0.0	0.0
23	Rock sole	284.6	446.0	152.0	131.8
24	Rock sole	116.0	106.0	61.8	56.2

Table 4 - Con't. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	Uncorrected CPUE (kg/h) WER	Corrected CPUE (kh/h) STD	Corrected CPUE (kh/h) WER
25	Rock sole	76.0	56.0	50.4	16.1
26	Rock sole	0.0	1.0	0.0	0.5
27	Rock sole	4.9	16.0	3.0	0.0
28	Rock sole	57.6	60.0	36.5	17.4
29	Rock sole	24.0	1184.0	14.9	844.7
30	Rock sole	168.0	148.0	121.9	81.6
31	Rock sole	24.0	112.0	11.9	71.1
32	Rock sole	472.0	172.0	334.5	103.5
33	Rock sole	66.0	68.0	31.2	15.2
34	Rock sole	78.2	84.0	50.0	21.3
35	Rock sole	318.9	194.0	119.3	55.8
36	Rock sole	138.0	62.0	65.0	15.1
37	Rock sole	34.0	76.0	19.4	40.3
38	Rock sole	28.8	0.0	9.8	0.0
39	Rock sole	6.2	4.0	4.3	2.1
40	Rock sole	51.7	2.0	32.9	1.1
41	Rock sole	0.0	0.0	0.0	0.0
42	Rock sole	0.9	1.0	1.5	0.5
43	Rock sole	0.0	6.0	0.0	3.2
44	Rock sole	0.0	0.0	0.0	0.0
45	Rock sole	0.0	0.0	0.0	0.0
46	Rock sole	0.0	0.0	0.0	0.0
47	Rock sole	11.1	18.0	7.1	9.5
48	Rock sole	0.0	0.0	0.0	0.0
1	Dover sole	6.0	0.0	7.7	0.0
2	Dover sole	1.0	14.0	0.7	1.1
3	Dover sole	0.0	1.0	0.0	0.2
4	Dover sole	0.0	0.0	0.0	0.0
5	Dover sole	3.8	0.0	5.0	0.0
6	Dover sole	6.9	34.0	3.5	2.4
7	Dover sole	0.0	154.0	0.0	5.3
8	Dover sole	0.0	2.0	0.0	0.4
9	Dover sole	0.0	0.0	0.0	0.0
10	Dover sole	0.0	0.0	0.0	0.0
11	Dover sole	1.0	2.0	0.0	0.4
12	Dover sole	258.0	12.0	207.0	6.7

Table 4 - Con't. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	WER	Corrected CPUE (kh/h) STD	WER
13	Dover sole	17.1	24.0	13.4	7.6
14	Dover sole	9.4	62.0	5.7	11.8
15	Dover sole	0.0	2.0	0.0	0.4
16	Dover sole	1.0	8.0	0.0	0.0
17	Dover sole	0.0	30.0	0.0	0.8
18	Dover sole	6.7	86.0	3.4	18.1
19	Dover sole	6.7	56.0	6.8	11.2
20	Dover sole	80.0	192.0	63.3	47.2
21	Dover sole	0.0	0.0	0.0	0.0
22	Dover sole	106.0	156.0	83.3	33.5
23	Dover sole	6.9	1.0	5.1	0.2
24	Dover sole	0.0	0.0	0.0	0.0
25	Dover sole	0.0	0.0	0.0	0.0
26	Dover sole	40.0	452.0	18.3	89.5
27	Dover sole	6.5	26.0	4.9	4.9
28	Dover sole	2.4	4.0	1.2	0.0
29	Dover sole	6.0	30.0	7.3	6.3
30	Dover sole	0.0	1.0	0.0	0.2
31	Dover sole	0.0	0.0	0.0	0.0
32	Dover sole	0.0	0.0	0.0	0.0
33	Dover sole	0.0	0.0	0.0	0.0
34	Dover sole	0.0	0.0	0.0	0.0
35	Dover sole	0.0	0.0	0.0	0.0
36	Dover sole	0.0	0.0	0.0	0.0
37	Dover sole	0.0	28.0	0.0	5.9
38	Dover sole	0.0	92.0	0.0	0.0
39	Dover sole	0.0	46.0	1.6	4.3
40	Dover sole	153.1	86.0	126.6	47.7
41	Dover sole	28.0	54.0	14.4	17.0
42	Dover sole	0.0	1.0	0.0	0.2
43	Dover sole	8.0	190.0	21.0	64.4
44	Dover sole	31.1	18.0	27.1	3.0
45	Dover sole	10.0	6.0	7.5	1.3
46	Dover sole	0.0	0.0	0.0	0.0
47	Dover sole	0.0	0.0	0.0	0.0
48	Dover sole	29.0	6.0	21.7	1.3

Table 4 - Con't. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	Uncorrected CPUE (kg/h) WER	Corrected CPUE (kh/h) STD	Corrected CPUE (kh/h) WER
1	English sole	2.0	0.0	0.0	0.0
2	English sole	2.0	18.0	1.7	8.7
3	English sole	5.8	8.0	3.5	5.7
4	English sole	0.0	0.0	2.5	0.0
5	English sole	65.6	0.0	29.4	0.0
6	English sole	13.7	10.0	3.4	1.8
7	English sole	16.9	208.0	12.6	22.1
8	English sole	0.0	138.0	0.0	27.1
9	English sole	3.4	8.0	1.4	0.8
10	English sole	0.0	12.0	0.0	0.0
11	English sole	44.0	144.0	3.1	4.1
12	English sole	88.5	2.0	17.9	0.0
13	English sole	32.6	24.0	6.2	4.3
14	English sole	86.3	138.0	12.7	16.7
15	English sole	102.0	256.0	31.4	26.0
16	English sole	44.5	194.0	8.5	11.1
17	English sole	28.3	72.0	11.7	6.5
18	English sole	46.7	66.0	18.7	18.5
19	English sole	51.7	104.0	20.3	32.9
20	English sole	50.9	172.0	24.0	55.2
21	English sole	75.4	320.0	20.2	61.5
22	English sole	62.0	114.0	20.4	34.7
23	English sole	8.6	4.0	3.6	1.1
24	English sole	2.0	2.0	0.7	0.6
25	English sole	8.0	104.0	5.3	20.4
26	English sole	38.0	40.0	14.3	6.7
27	English sole	98.9	94.0	27.3	13.2
28	English sole	86.4	126.0	24.6	9.3
29	English sole	28.0	132.0	6.3	28.0
30	English sole	62.0	70.0	21.8	6.5
31	English sole	3.4	2.0	1.9	0.0
32	English sole	0.0	1.0	0.0	0.3
33	English sole	2.0	4.0	1.1	0.0
34	English sole	0.0	1.0	0.0	0.3
35	English sole	5.1	4.0	1.6	1.1
36	English sole	4.0	1.0	4.3	0.3

Table 4 - Con't. Uncorrected and corrected CPUE for four commercial species caught on the 1996 Hecate Strait survey by vessel, species and replicate.

Replicate	Species	Uncorrected CPUE (kg/h) STD	Uncorrected CPUE (kg/h) WER	Corrected CPUE (kh/h) STD	Corrected CPUE (kh/h) WER
37	English sole	1186.0	1550.0	196.0	434.0
38	English sole	592.8	340.0	226.0	63.7
39	English sole	333.1	678.0	129.7	261.7
40	English sole	229.7	76.0	170.1	52.2
41	English sole	766.0	624.0	431.3	410.2
42	English sole	254.1	146.0	103.1	35.6
43	English sole	108.0	648.0	51.6	237.6
44	English sole	153.3	182.0	39.3	17.6
45	English sole	242.0	664.0	104.9	123.0
46	English sole	181.7	186.0	124.2	52.1
47	English sole	364.4	18.0	187.7	5.0
48	English sole	38.7	60.0	14.8	52.9

Table 5. Summary statistics for uncorrected CPUE (kg/h) by species and vessel.

	n[1]	Mean		Median		Standard deviation		90% confidence interval	
Species		WER	STD	WER	STD	WER	STD	WER.	STD
Pacific Cod	13	58.7	69.9	6.0	10.0	188.0	137.5	14.1-103.3	37.2-102.6
Rock Sole	15	64.2	66.2	1.5	5.6	182.5	149.3	20.9-107.5	30.8-101.6
English Sole	2	161.8	117.1	74.0	44.3	273.0	219.0	97.0-226.6	65.1-169.1
Dover Sole	16	39.1	17.2	5.0	0.5	79.0	45.8	20.4-57.8	6.3-28.1

[1] Number of hauls where the catch of both vessels was zero.

Table 6. Summary statistics for corrected CPUE (kg/h) by species and vessel.

	n[1]	Mean		Median		Standard deviation		90% confidence interval	
Species		WER	STD	WER	STD	WER	STD	WER.	STD
Pacific Cod	13	56.0	62.7	3.5	10.1	181.1	119.3	13.0-99.0	34.4-91.0
Rock Sole	15	34.0	42.5	0.5	3.4	123.4	107.4	4.7-63.3	17.0-68.0
English Sole	2	45.2	44.6	10.2	13.5	95.2	81.1	22.6-67.8	25.3-63.9
Dover Sole	16	8.2	13.7	0.4	0.0	18.3	36.8	3.9-12.5	5.0-22.4

[1] Number of hauls where the catch of both vessels was zero

Table 7. Summary statistics for length data (cm) collected during the R/V W.E. RICKER assemblage survey, Hecate Strait, May 29 - June 14, 1996.

Species	Mean	Standard Deviation	Median	Mode	n
Pacific Cod	50.3	16.2	52	28,47,61	461
Rock Sole	26.9	8.2	26	20,33	2541
Dover sole	28.5	5.1	29	30	2386
English sole	27.1	5.8	27	26	8455

Table 8. Summary statistics for length data (cm) collected on the F/V STEADFAST, for the 1996 Hecate Strait survey, June 1-6, 1996.

Species	Mean	Standard Deviation	Median	Mode	n
Pacific Cod	54.7	13.4	53	32,48	635
Rock Sole	35.3	4.7	35	34	1709
Dover sole	38.9	6.5	39	33,43	567
English sole	31.4	4.7	31	33	3781

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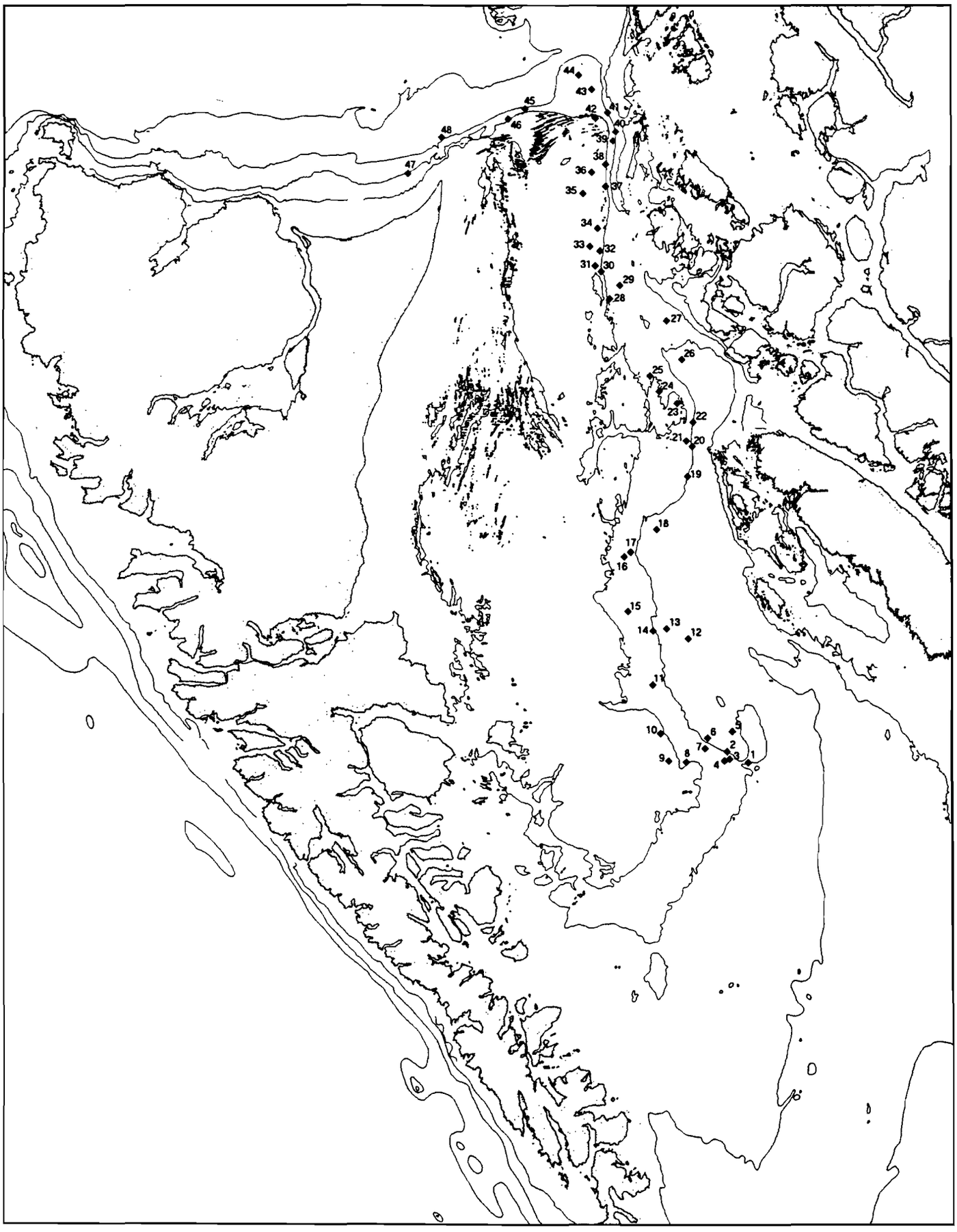

Fig. 1. Location of replicate hauls made by the W. E. RICKER AND STEADFAST during the 1996 Hecate Strait survey.

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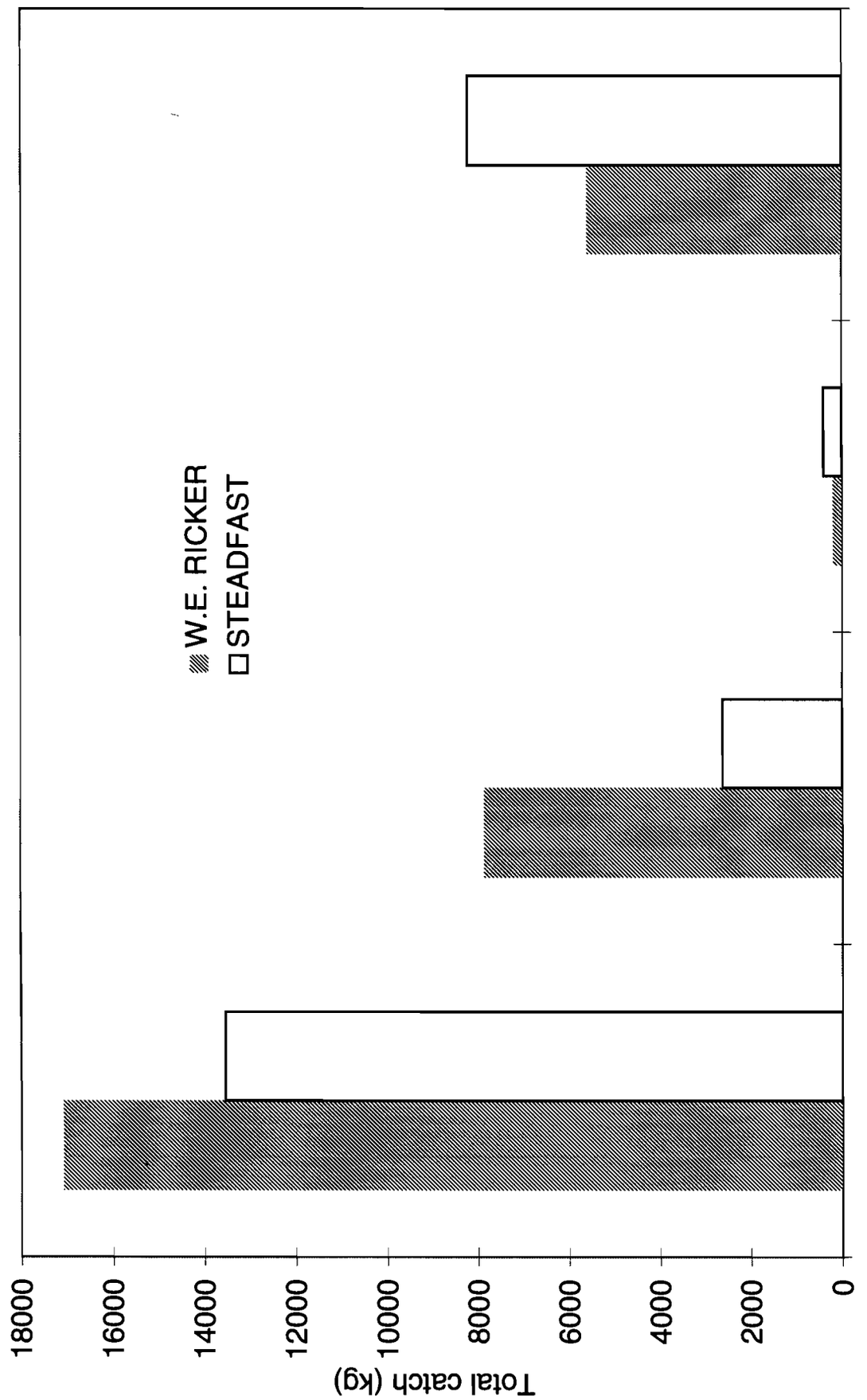

Fig. 2. Catch composition (weight) by species group by vessel.

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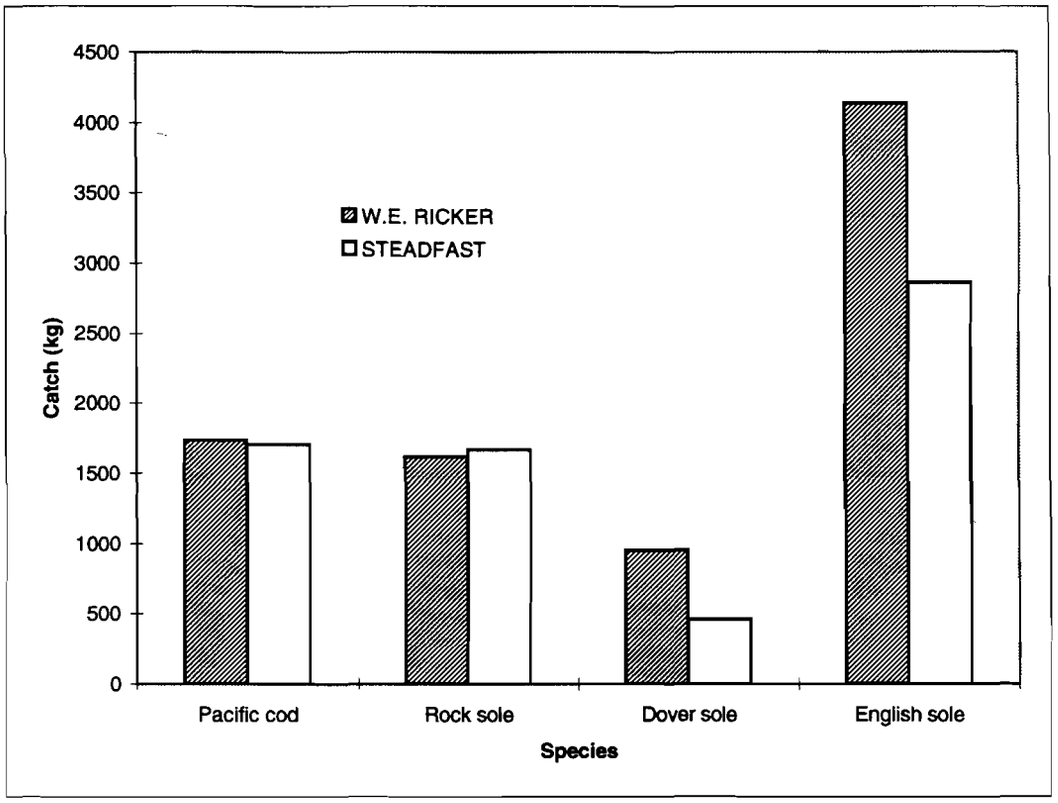

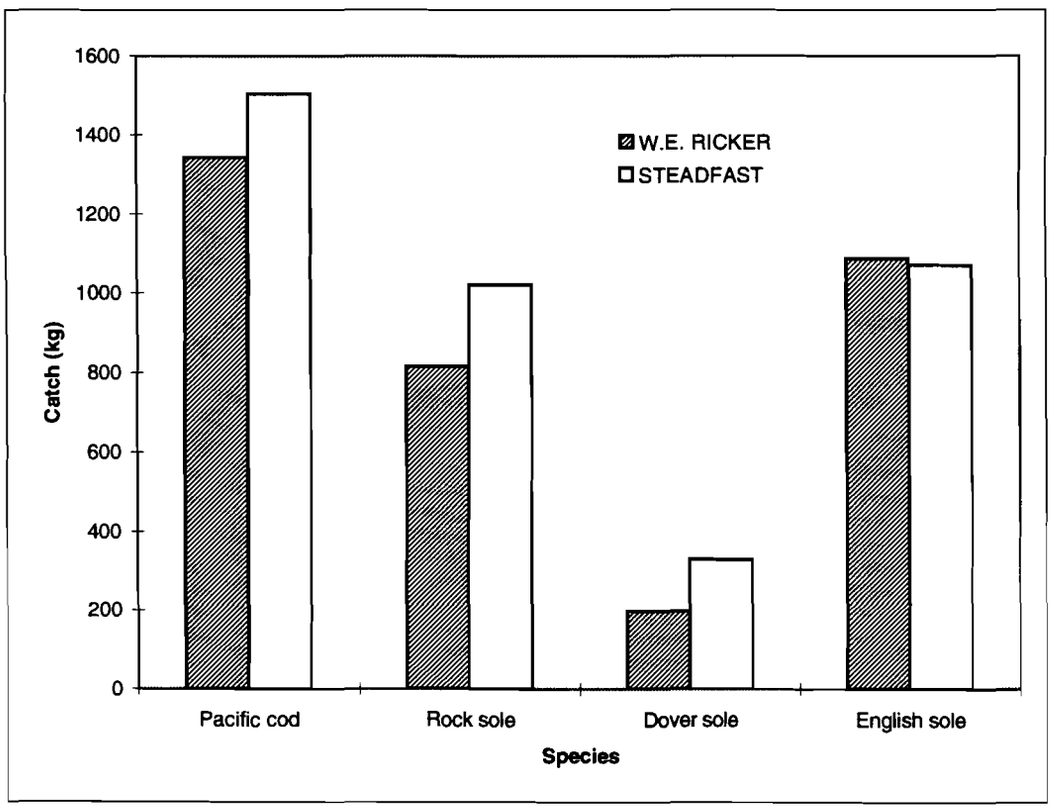

Fig. 3. Uncorrected (top panel) and corrected (bottom panel) catch for four commercial species by vessel.

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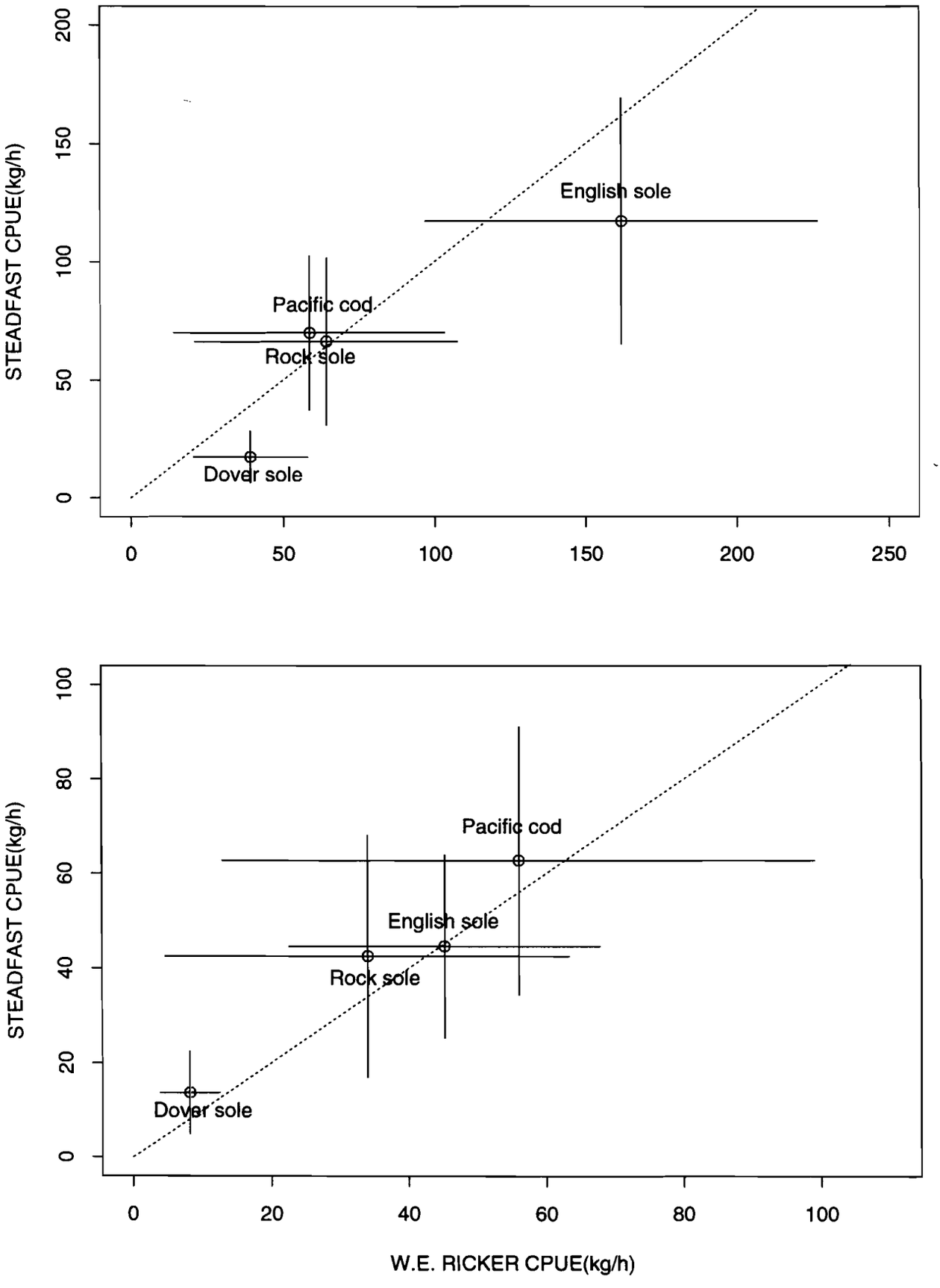

Fig. 4. Uncorrected (top panel) and corrected (bottom panel) mean CPUE by species and vessel. The crosses represent the 90% confidence intervals and the dotted line is the line of 1:1 correspondence.

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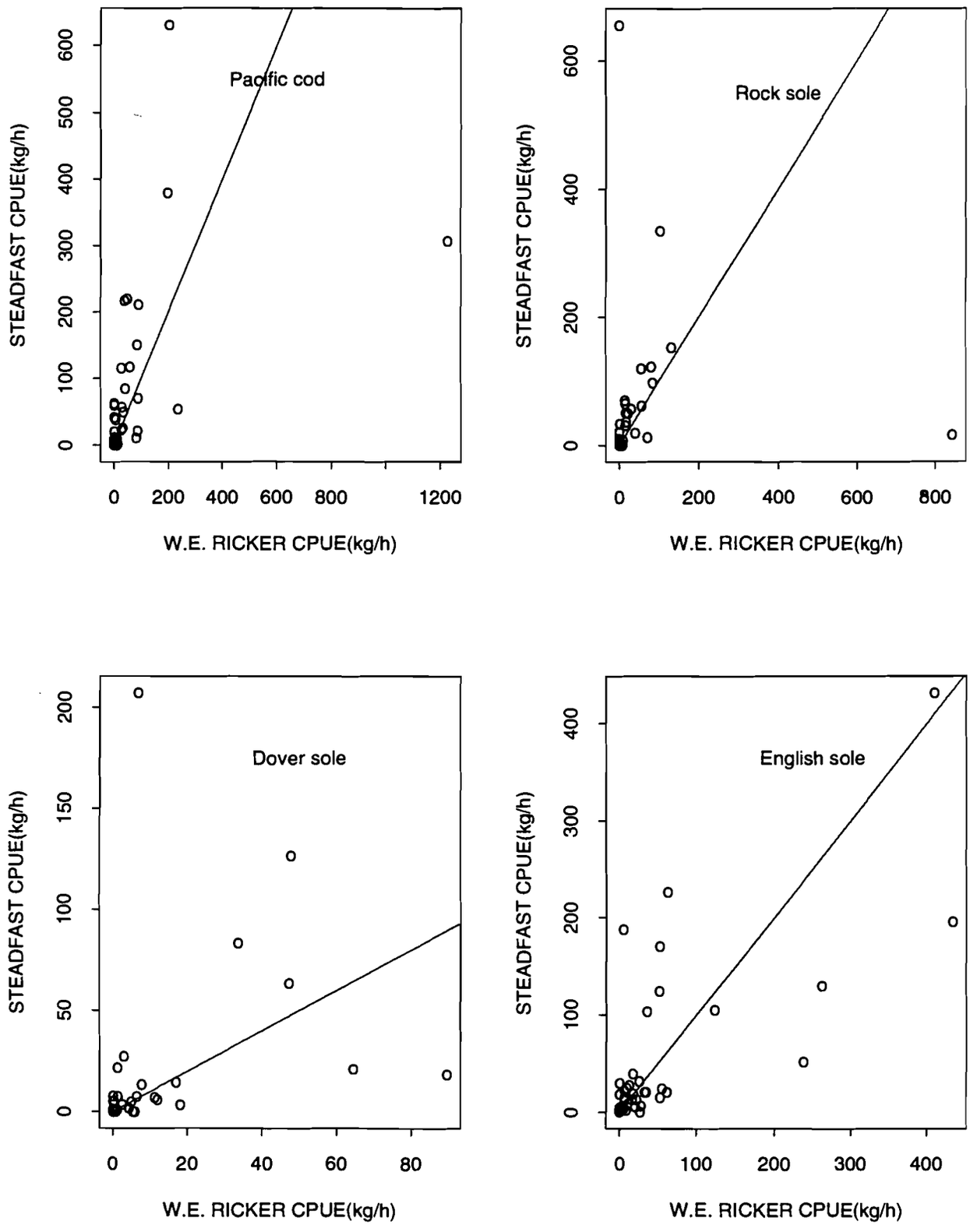

Fig. 5. Corrected CPUE by species and vessel. The diagonal line in the plots indicates 1:1 correspondence.

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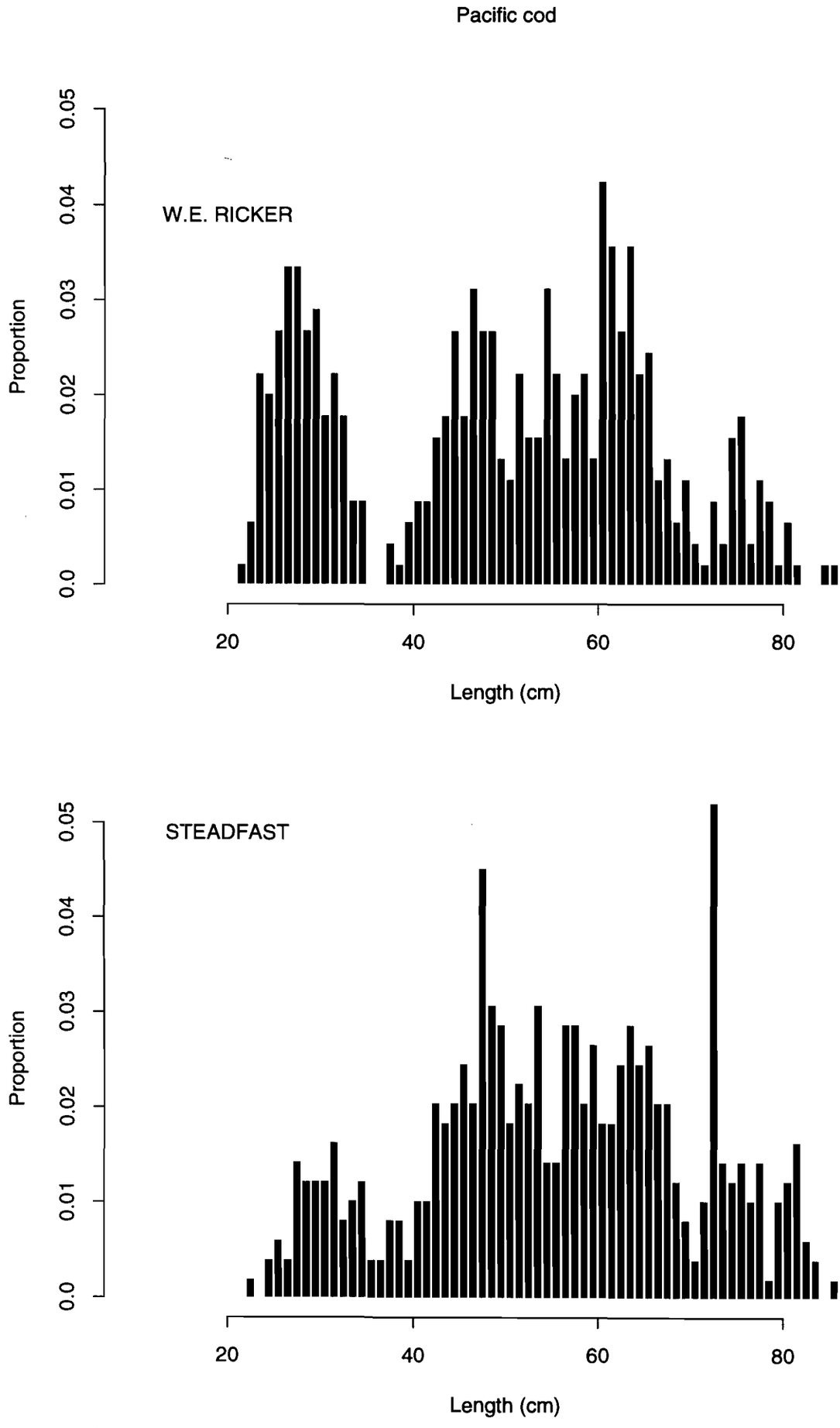

Fig. 6. Length frequency histograms for Pacific cod by vessel.

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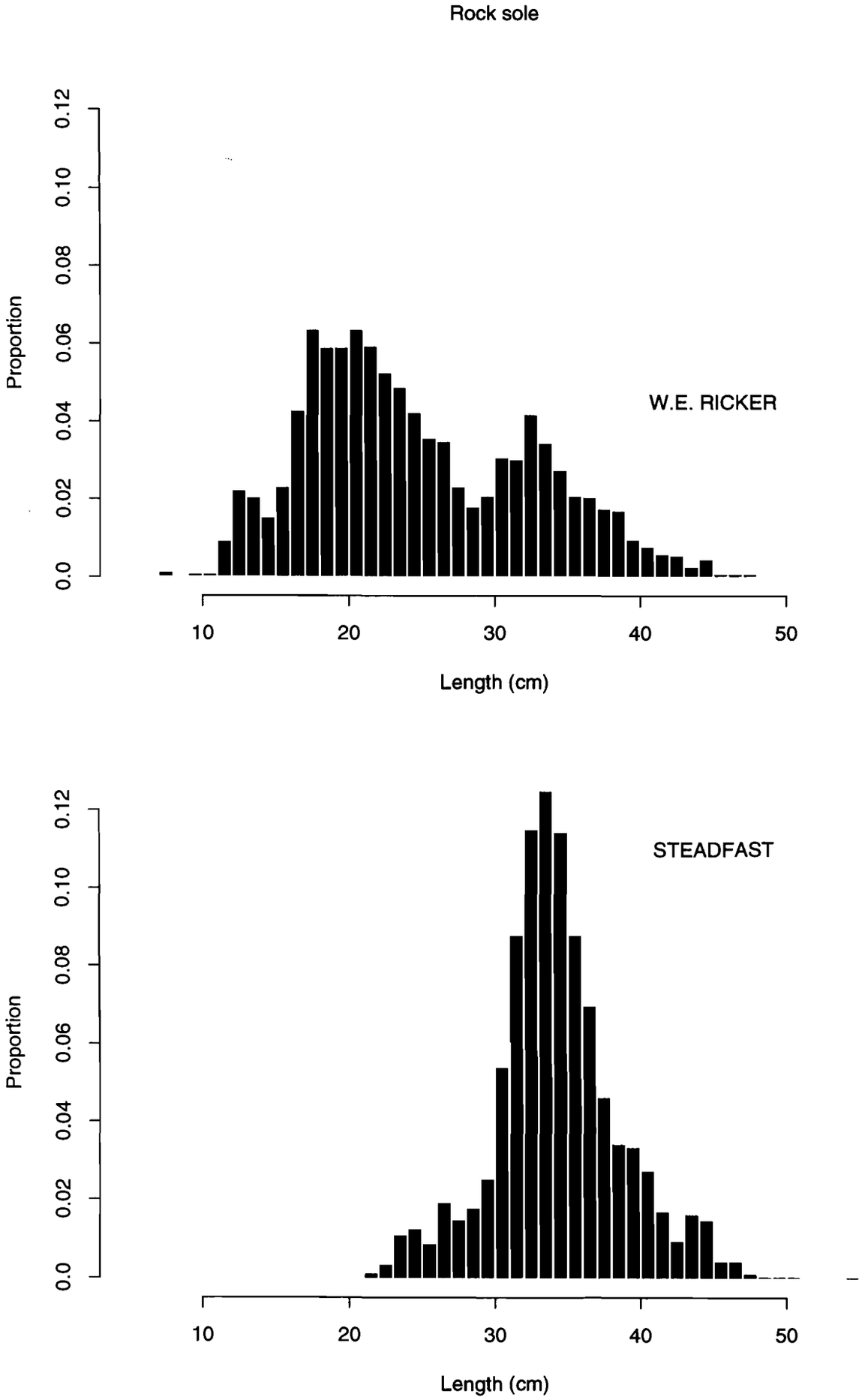

Fig. 7. Length frequency histograms for Rock sole by vessel.

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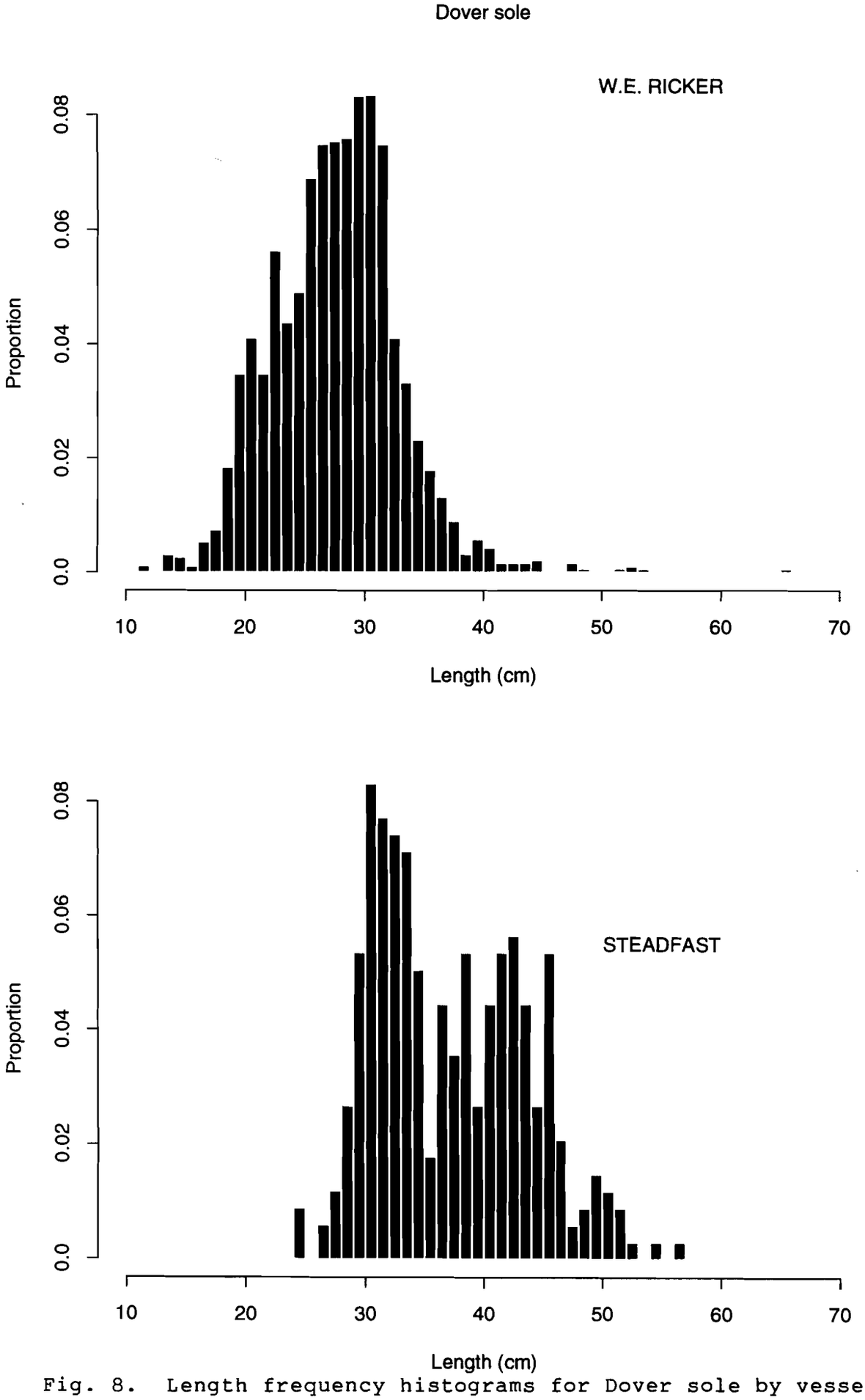

Fig. 8. Length frequency histograms for Dover sole by vessel.

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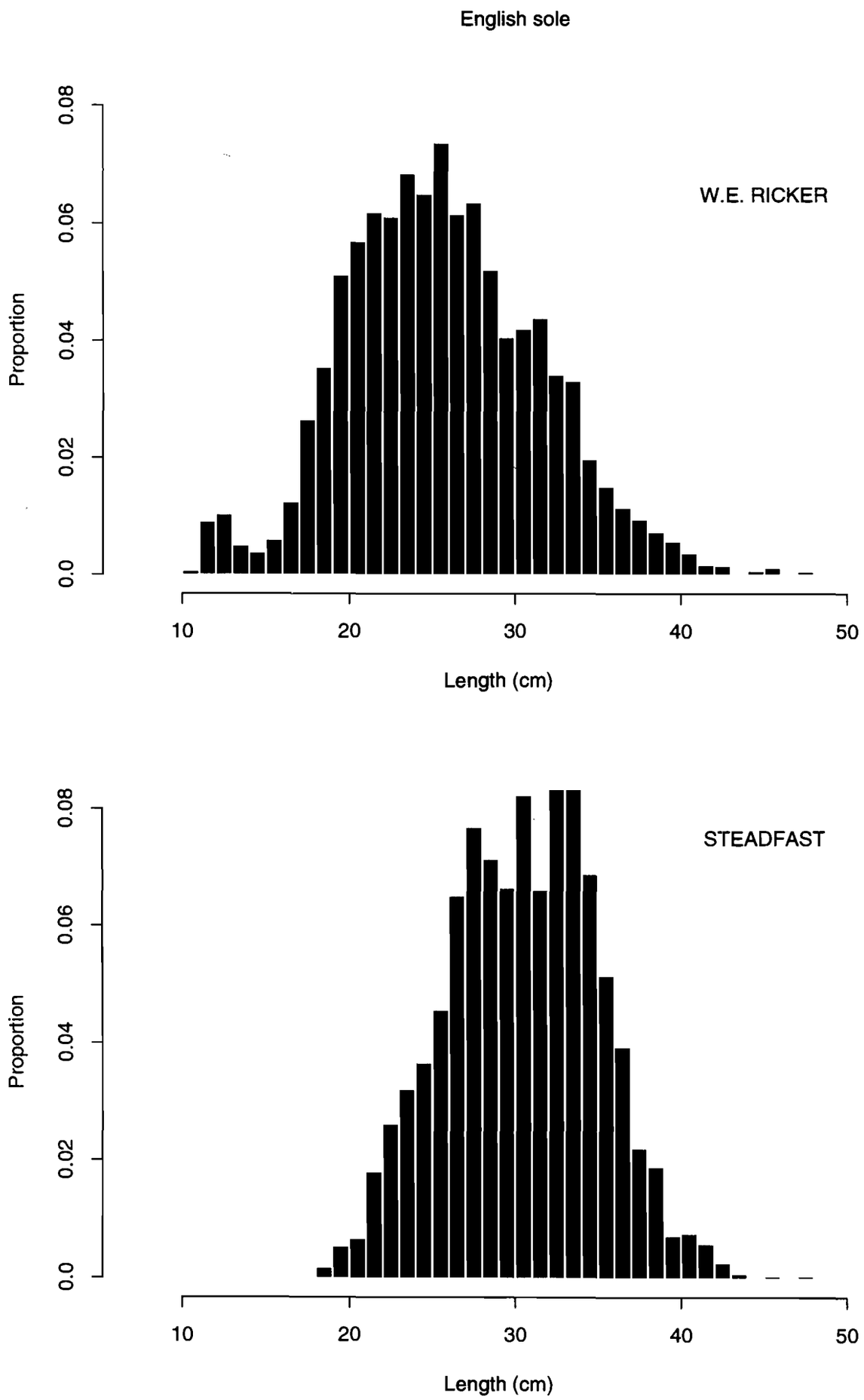

Fig. 9. Length frequency histograms for English sole by vessel.

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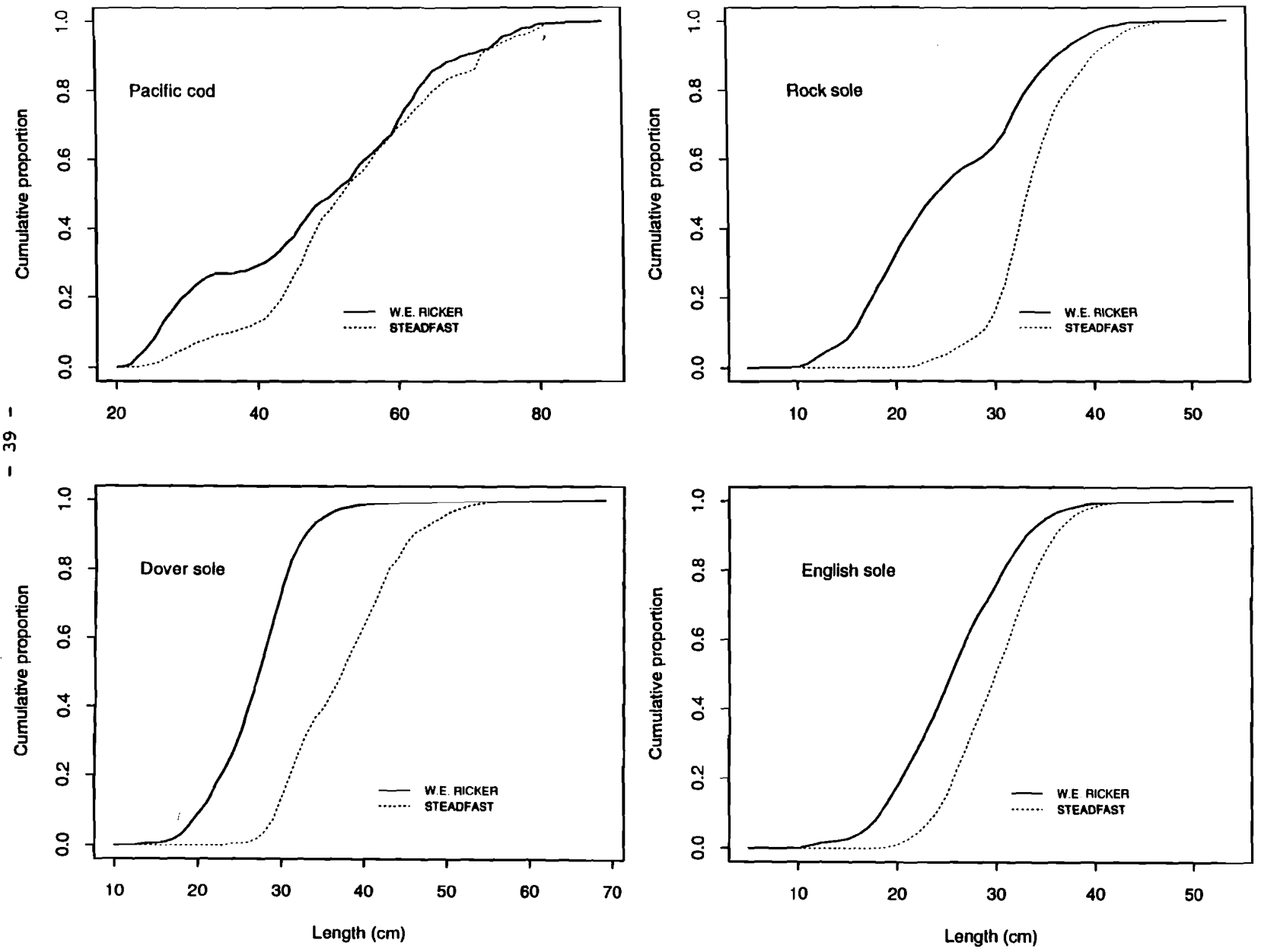

Fig. 10. Species cumulative length frequency by vessel.

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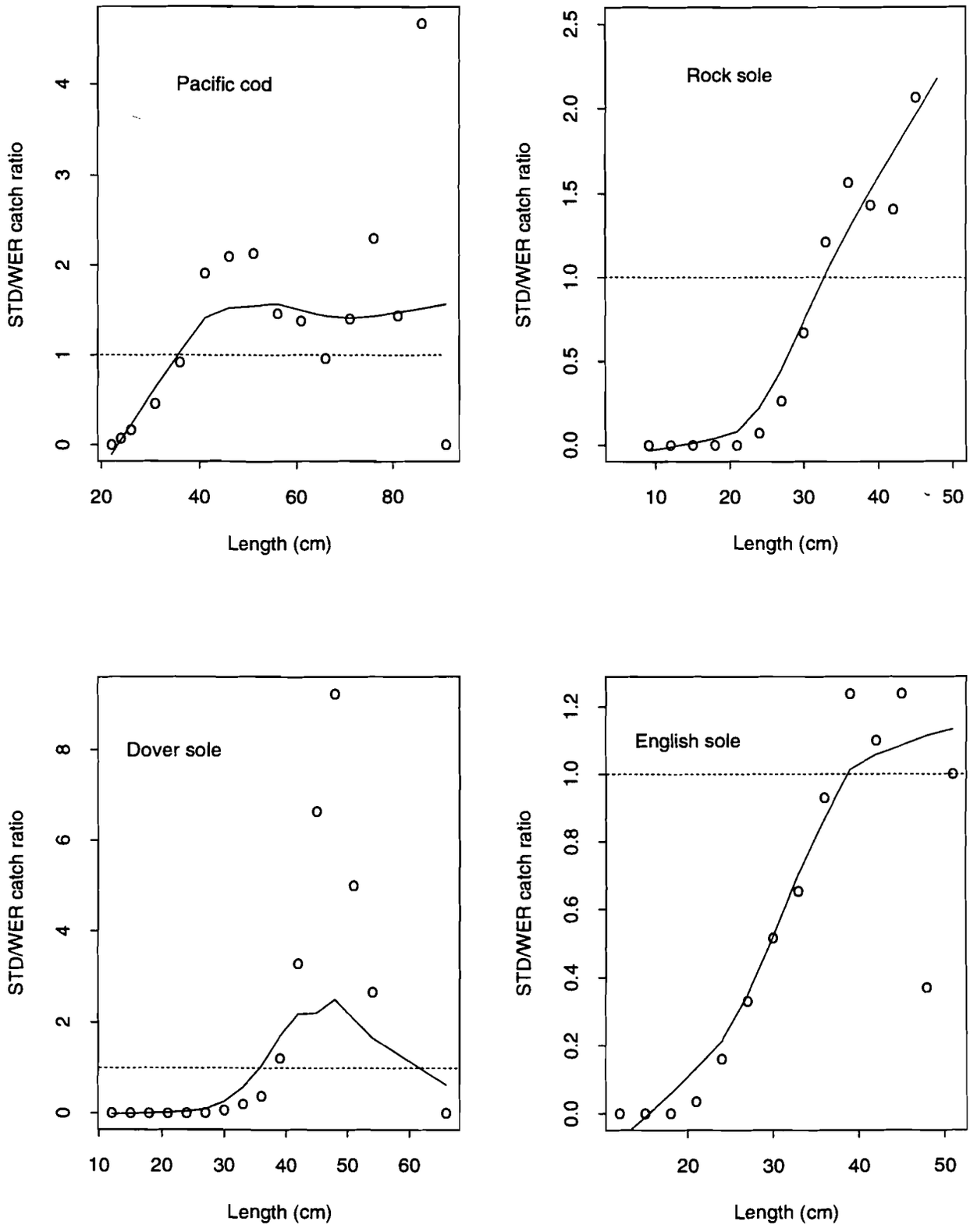

Fig. 11. Selectivity ratios by species length category for the STEADFAST in comparison with the W. E. RICKER. The line in each plot represents the lowess smoothed fit.