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Effect of Mesh Size/Type on Size Distribution and Catch Rates for 1991 Scotian Shelf Groundfish Fisheries

by

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Abstract

In recent years attempts have been made to reduce fishing pressure on Scotia Shelf cod, haddock, and pollock stocks through changes in mesh regulations. In 1991, proposed changes included increase in traditional diamond mesh and the use of square mesh. However, complications in the implementation of these regulatory changes resulted in a wide range of mesh sizes and configurations being fished concurrently through 1991. This situation presented a unique opportunity to evaluate the effectiveness of the mesh changes under actual commercial fishing operations.

Observations were made using sea-going Observers, who collected data on catch, size distribution, and mesh size/type. Data were analyzed from the following groundfish stocks: 4Vn (winter) cod, 4VsW cod, 5Z cod, 5Z haddock, and 4VWX+5 pollock. Size distribution of the catch, as well as catch rates, are compared between the various mesh size/types, and evaluated against theoretical retention curves.

Introduction

In recent years attempts have been made to reduce pressure on traditional Scotian Shelf groundfish stocks through regulatory measures. One technique is to increase the minimum codend mesh size permitted in otter trawl fisheries, thus reducing the catch of younger year classes; for example in the mid-eighties codend mesh size regulations were changed from 120mm to 130mm (Waldron *et al.*, 1985). This strategy produces a short-term loss in catch, but in theory increases over a longer term.

The determination of appropriate changes in trawl mesh regulations involves a number of steps. Retention curves from other areas and/or species are considered to develop theoretical changes in selection properties of the trawl. This is usually followed by a series of experiments under controlled conditions, on both research and chartered commercial vessels. It is hoped that results derived from these theoretical and experimental development steps will apply to the commercial fishery. Unfortunately, the conditions under which the fishing gear is used in commercial operations may seriously interfere with the selection characteristics of the mesh. These factors can range from subtle changes in the manner in which the mesh is attached to the trawl, to deliberate attempts to block the mesh openings. Furthermore, it is often very difficult to evaluate the results of the changes in commercial mesh regulations. Changes are usually implemented en mass at the beginning of a fishing year, so comparisons of different gears within a year are not possible. Likewise, variations in age structure of the population from year to year due to recruitment make comparisons between years difficult.

The continued decline of cod, haddock, and pollock stocks on the Scotia Shelf since this time have sparked further changes in both gear technology and regulations. In 1990 130 and 140mm square mesh gear was fished on a trial basis by TC 1-3 vessels in southwest Nova Scotia. This change in mesh configuration allowed openings in the codend to remain unrestricted, thus allowing for the escape of small fish. Reaction by the fishermen to the square mesh gear was generally favourable during this period.

In January, 1991, mesh regulations were amended to allow 155mm diamond or 140mm square mesh codends only, for cod, haddock, and pollock fisheries. Concerns over the new regulations were expressed stridently by representative of the fishing industry as the fishing season progressed. This resulted in a Ministerial directive in June, decreasing the minimum mesh sizes to 140 diamond or 130 square. Further, fishery officers were instructed to enforce the mesh size regulations through warnings only.

This regulatory confusion resulted in an unprecedented number of gear sizes and configurations being used on the Scotian Shelf in 1991. This provided a unique opportunity to compare catch characteristics of the various gears, through information provided by the Scotia-Fundy Observer Program. The following report provides comparisons of catch rate and size distribution Scotia Fundy groundfish stocks fished under this regulatory regime.

Methods

All data were collected through the Scotia Fundy Observer Program. Deployments were made to both the inshore (<65'; TC 1-3) and the offshore (>100'; TC 5-7) fleets. Observers from Scotia Fundy Region are routinely deployed to monitor fishing operations in the Canadian groundfish fishery for the following stocks: 4Vn (winter) cod, 4VsW cod, 5Z cod, 5Z haddock, 4VSW+5 pollock. Coverage for small vessels was approximately 5% of the total fishing days, while offshore vessel coverage was almost 50%.

Estimates of catch were made visually on a set-by-set basis, and verified through volumetric calculations and observation of crew production. Length frequencies were taken from the unculled catch, with random selection, from approximately 50% of the sets.

Codend mesh size was recorded as stated by the bosun or Captain on each vessel. This stated size was confirmed by the observer, using a ruler. As these measurements were not made using an approved gauge, they must be considered nominal.

For analysis, directed species was taken to be the species which made up the largest proportion (by weight) of the catch in any particular set. Catch and effort data were summarized for successful sets only, excluding sets where substantial gear damage occurred or where a codend window was employed. To minimize random effects, calculations of CPUE were restricted to mesh size/type combinations with more than 25 tons of catch in total.

Sampling for unculled length distribution of the catch was performed on approximately 25% of the fishing sets.

Numbers at length in sampled catches were adjusted for the size of the catch before pooling. For some stocks small numbers of length frequency samples precluded the comparison of length frequency distributions between gear configurations. Length frequency proportions were plotted only where the number of fish measured exceeded 1000; comparisons were made where two or more distributions were available.

Where data were sufficient, cumulative percent curves were calculated for each stock and mesh size/type combination. To facilitate comparison of different mesh types within a stock, two mesh selection parameters were calculated - length of 50% retention (l_{50}) and selection range (SR; length range between 25 and 75 % retention.

To compare observed length distributions with those expected from experimental studies, predicted numbers at age were taken from analytical assessments for the following stocks; 4VsW cod (Mohn & MacEachern, 1992), 5Z cod (Hunt & Buzeta, 1992) and 4VWX+5 pollock (Annand & Beanlands, 1992). Numbers at length were calculated from numbers at age using appropriate age-length keys. The theoretical proportion of fish retained by length group was taken from Halliday & White, 1989 for diamond mesh, and Halliday, 1993 for square mesh. Expected numbers at length in the catch were calculated by multiplying the calculated proportion at length in the population by the mesh retention proportion at length.

Results and Discussion

Distribution of vessel and gear combinations.

Distribution of the observed sets by stock and gear is summarized in Table 1. TC 1-3 vessels fished with the largest variety of gears, although very few sets were made directing for cod in 4Vn or 4VsW. Square mesh was employed almost exclusively by the small dragger fleet, predominantly in SW Nova (4X, 5Z). TC 5+ vessels as a rule fished with diamond mesh, about evenly split between 140 and >150mm.

Size Distribution - Commercial Fishery.

4Vn (winter) cod

This stock is fished predominantly by TC 5+ draggers, and hence sufficient data were available for diamond mesh codends only. 1,650 tons of catch were observed in total (Table 2), with over 20,000 fish measured. A good distribution over the three mesh sizes (130, 140, & 155 mm) codends used (Fig. 2).

In general, distribution of the catch by length was as expected, with 130 mm mesh showed a definite trend to select smaller fish over larger mesh (l_{50} of 48 vs 50). However, the difference was less clear between 140 mm and 155 mm mesh (Table 3, Fig. 7).

4VsW cod

Observer coverage of this stock was principally on large TC 5+ vessels. Almost 5,000 tons of catch was observed over the course of the fishery (Table 2), from which over 40,000 fish were measured. The most common codend mesh used were 140 and 155 diamond, although 130 diamond accounted for slightly over 10% of the catch. There was no significant use of square mesh.

Selection parameters for the 130 and 140 mm diamond mesh codends were identical, with an l_{50} of 49 cm and selection range of 10 cm. Sets with a mesh size of 155 mm diamond showed a shift of 3 cm in l_{50}, to 52 cm (Table 3, Fig. 8).

5Z cod

The Georges Bank fishing ground (5Z) is fished principally by small draggers (TC 1-3). In total almost 400 tons catch was observed for this stock, with this fleet accounting for 75% of the total. 140 mm diamond mesh was used most frequently, and accounted for 60% of the total catch. 130 mm and 140 mm square mesh was used to take 29 and 98 tons, respectively (Table 2).

Mesh selection trends for this stock are unusual. Square mesh, both 130 mm and 140 mm, appears to retain smaller fish than 140 mm diamond mesh. This is counter intuitive, and difficult to explain (Fig. 9). l_{50} for each mesh size/type is high, ranging from 58 cm to 67 cm (Table 3). These values are higher than those reported for cod (Halliday, 1993).

5Z haddock

Total observed landings in 1991 for this stock were the lowest of the five studied, at 123 tons. Most coverage was on small vessels (TC 1-3), where three gear types accounted for slightly over 100 tons of this catch; 140 mm diamond mesh most common, followed by 130 mm and 140 mm square (Table 2). Length sampling amounted to a total of 4,337 fish.

For this stock square mesh showed a distinct selection pattern for larger fish, with an l_{50} of 53 vs 55 for 130 mm and 140 mm square mesh. Little difference was seen in mesh selection characteristics between the two types of square mesh (Table 3, Fig. 10).

4VWX+5 pollock

Diamond mesh codends of 140 mm and 155 mm predominated in this fishery, and accounted for over 95% of the observed catch. Sampling for these two gear types was extensive, with almost 50,000 fish measured in total.

Mesh selection parameters are presented in Table 2 and Fig. 11. While the mesh type in each ogive is diamond, the l_{50} for each is identical at 61 cm. However, the selection range did change between types; 155 mm diamond mesh showed a narrower range at 11 cm vs 14.

Comparison with calculated length distributions.

Sequential population analyses and age length keys were available for 4VsW cod, 5Z cod, and 4VWX+5 pollock. Numbers at age were converted to proportions at length and 'fished' with each gear's selectivity pattern. Results are presented in Fig. 12 for all mesh sizes/types were a comparison was possible.

4VsW cod

Based on theoretical selection characteristics, a difference in l_{50} of approximately 3 and 10 cm should be seen for 140 mm and 155 mm mesh respectively, over 130mm (Fig. 12a). Calculated vs observed cumulative percent curves for this stock are shown in Fig. 13. The ogives for 130 mm mesh showed close correspondence. However, at 140 mm mesh, the l_{50} differed by 2 cm between calculated and observed; at 155 mm the l_{50} was shifted only 3 cm over the 130 mm value. Hence, although the 155 mm mesh tends to select for larger fish, the difference is much smaller than might be expected from theoretical calculations.

5Z cod

Calculated and observed distributions bear very little resemblance to each other, particularly at smaller lengths. This result may be an artifact of the distribution of the population, as almost 60% by number are below 50 cm. In addition, sample numbers are small relative to the other stocks presented. However, it is worth noting that in an analysis of similar commercial data from the 1990 fishery, a similar pattern was noted for this stock (Showell, 1990).

4VWX+5 pollock

Results of theoretical distribution calculations are shown in Fig. 12c; for this stock a mesh increase from 140 mm to 155 mm diamond mesh should produce a change in l_{50} of approximately 2 cm. At 140 mm the observed curve showed close correspondence with the calculated curve (Fig. 15). This correspondence was not apparent with a mesh size of 155 mm; however, a narrower selection range was evident.

CPUE

Changing mesh size to allow the escapement of smaller fish is in turn increases the fishing effort required to realize the same catch. Under these conditions a drop in CPUE should be expected as mesh size increases. Similarly, square mesh should show a lower CPUE than diamond mesh of equivalent size. For three stocks (4Vn & 4VsW cod, 4VWX+5 pollock) this was generally the case (Fig. 16), with CPUE decreasing with increasing mesh size. For stocks where comparisons were made between diamond and square mesh types (5Z cod & haddock), the results were less conclusive (Fig. 17).

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TC 1 - 3

	# Sets				
Stock	130 mm Dia.	140 mm Dia.	>150 mm Dia.	130 mm Sq.	140 mm Sq
4Vn Cod (Winter)	12	39	-	-	-
4VsW Cod	3		1	-	-
4X Cod	1	10	7	79	71
5Z Cod	6	31	12	78	164
4X Haddock	7	4	1	13	16
5Z Haddock	2	28	1	48	62
4VWX+5 Pollock	19	62	23	14	56

TC 5 - 7

	# Sets			
Stock	130 mm Dia.	140 mm Dia.	>150 mm Dia.	140 mm Sq.
4Vn Cod (Winter)	66	176	56	3
4VsW Cod	122	781	741	5
4X Cod	-	13	29	-
5Z Cod	-	76	27	-
4TVW Haddock	-	68	28	-
4X Haddock	-	10	14	-
5Z Haddock	-	54	26	-
4VWX+5 Pollock	5	508	1,326	-

Table 1. Distribution of observed sets by main species caught and gear type.

Stock	130 mm Dia.	140 mm Dia.	>150 mm Dia.	130 mm Sq.	140 mm Sq.
4Vn Cod					
CPUE (t/h)	4.96	1.78	2.00	-	1.07
% Disc.	4.8	8.9	3.9	-	3.5
# Sets	78	215	56	-	3
Catch (t)	605	818	227	-	8
4VsW Cod					
CPUE (t/h)	2.56	1.44	1.28	-	1.14
% Disc.	3.4	9.7	4.8	-	3.3
# Sets	125	781	742	-	6
Catch (t)	606	2265	2066	-	12
4X Cod					
CPUE (t/h)	0.31	0.35	0.16	0.14	0.12
% Disc.	0	0.4	1.4	0.1	0.1
# Sets	1	23	36	79	71
Catch (t)	.4	16	13	36	26
5Z Cod					
CPUE (t/h)	0.28	0.77	0.22	0.10	0.19
% Disc.	0.4	0.2	2.6	0.5	0.1
# Sets	6	107	39	78	164
Catch (t)	5	231	23	29	98
4TVW Haddock					
CPUE (t/h)	-	0.38	0.21	-	-
% Disc.	-	3.7	5.1	-	-
# Sets	-	66	28	-	-
Catch (t)	-	55	12	-	-
4X Haddock					
CPUE (t/h)	0.78	0.35	0.27	0.13	0.17
% Disc.	0.4	0.5	3.0	4.9	0
# Sets	7	14	36	13	17
Catch (t)	7	14	7	6	10
5Z Haddock					
CPUE (t/h)	0.33	0.24	0.28	0.21	0.14
% Disc.	6.2	0.5	0	0	0
# Sets	2	82	27	48	62
Catch (t)	3	52	16	25	27
4VWX+5 Pollock					
CPUE (t/h)	2.2	1.26	0.88	0.43	0.46
% Disc.	0.2	0.8	0.6	0	0.7
# Sets	24	570	1349	14	56
Catch (t)	71	1489	2559	13	59

Table 2. Catch, CPUE, and discard proportion for Scotian Shelf groundfish stocks.

stock	mesh	l_{50}	SR
4Vn cod (win)	130D	48	12
	140D	50	9
	155D	50	12
4VsW cod	130D	49	10
	140D	49	10
	155D	52	11
5Z cod	140D	67	19
	130S	58	12
	140S	63	12
5Z haddock	140D	53	8
	130S	55	8
	140S	55	7
4VWX+5	140D	61	14
pollock	155D	61	11

Table 3: Length of 50% retention (l_{50}) and selection range (SR) for observed commercial catches of Scotian Shelf groundfish species in 1991. Data are grouped by mesh size and type

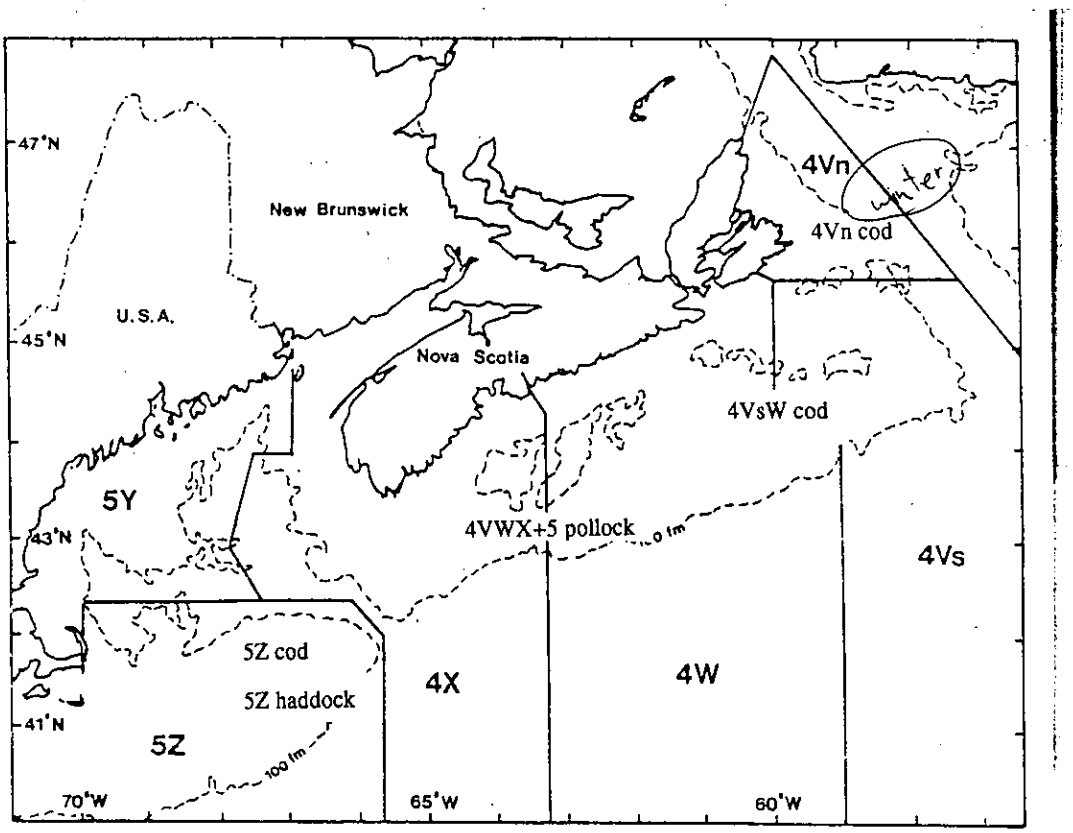

Figure 1. NAFO statistical divisions in the Scotia-Fundy Region.

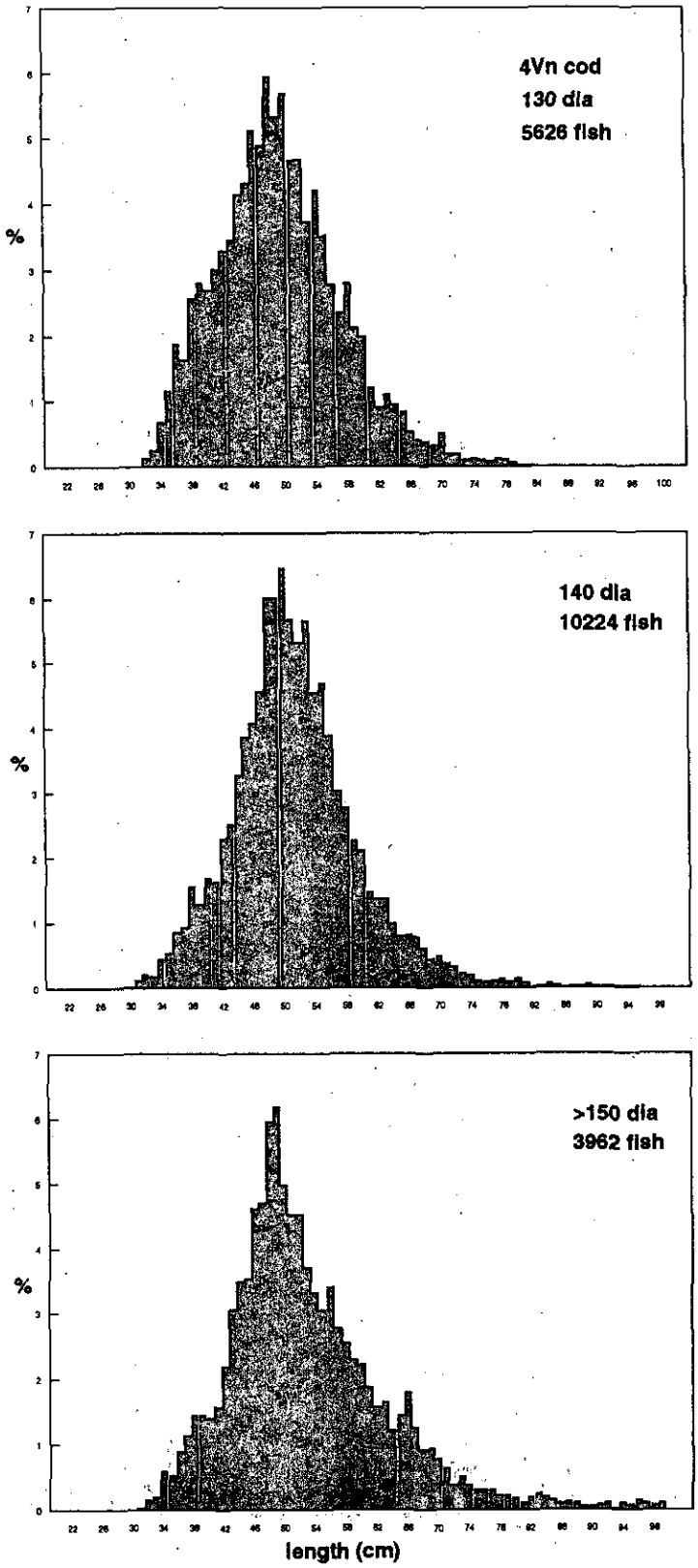

Figure 2: Length frequency distribution for 4Vn cod (winter); commercial fishery using 130mm diamond, 140mm diamond, and >150mm diamond mesh OTB gear.

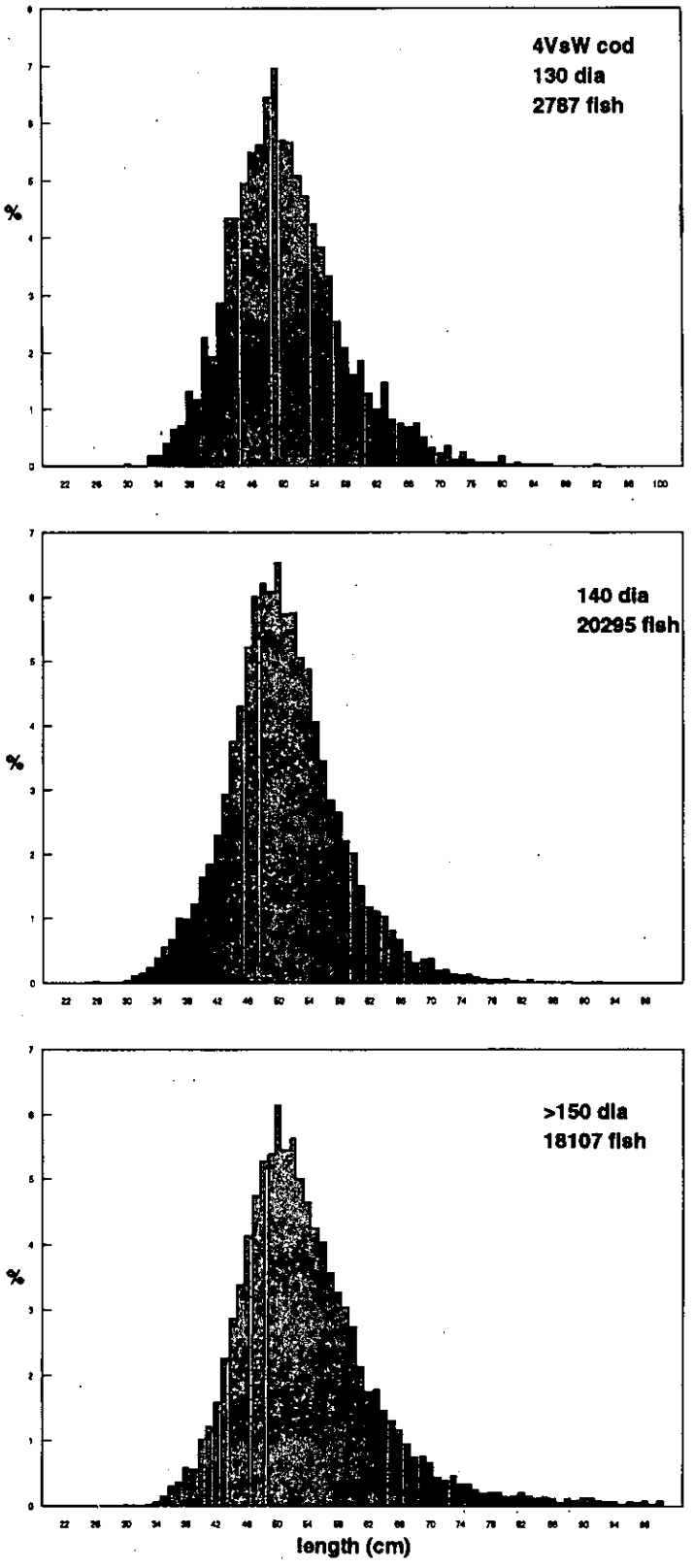

Figure 3: Length frequency distribution for 4VsW cod; commercial fishery using 130mm diamond, 140mm diamond, and >150mm diamond mesh OTB gear.

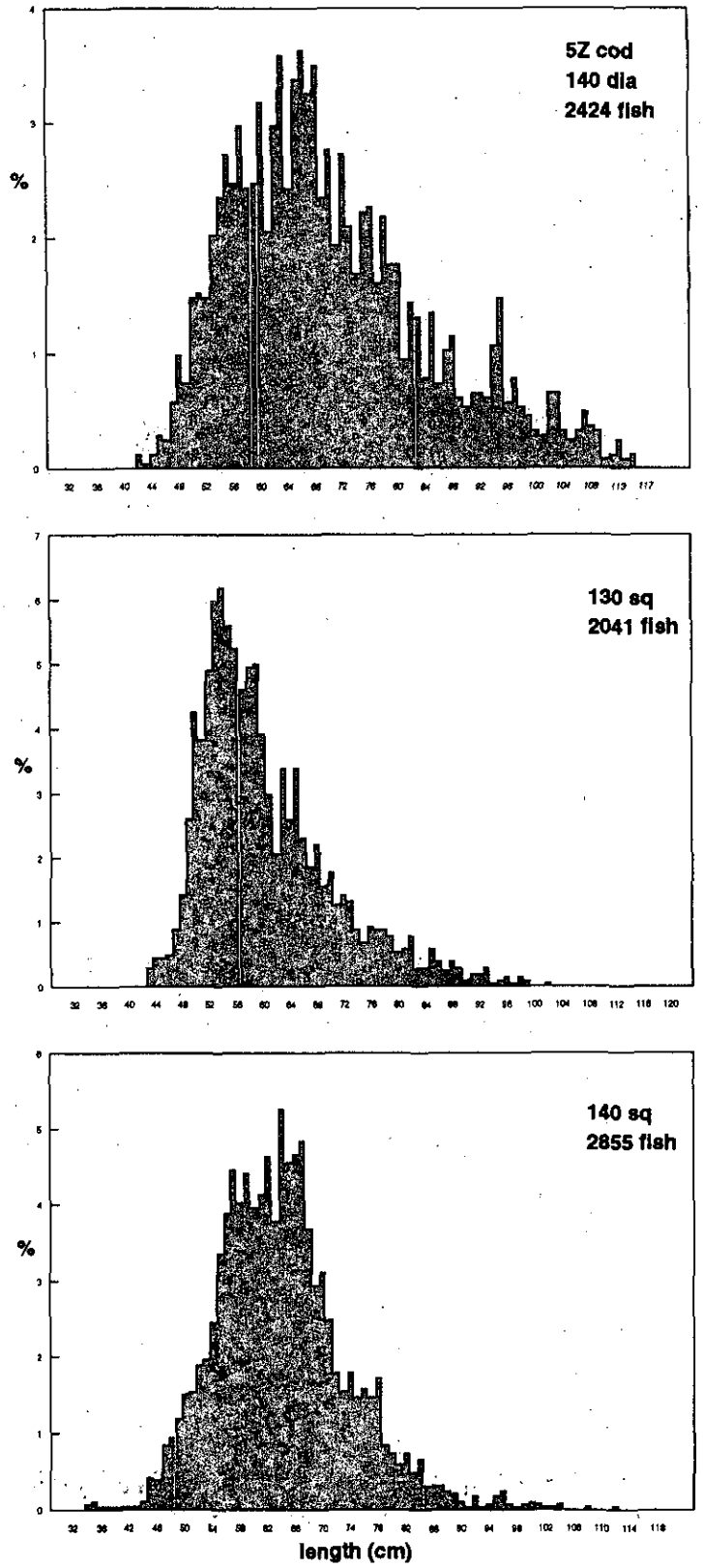

Figure 4: Length frequency distribution for 5Z cod; commercial fishery using 140mm diamond, 130 square, and 140mm square mesh OTB gear.

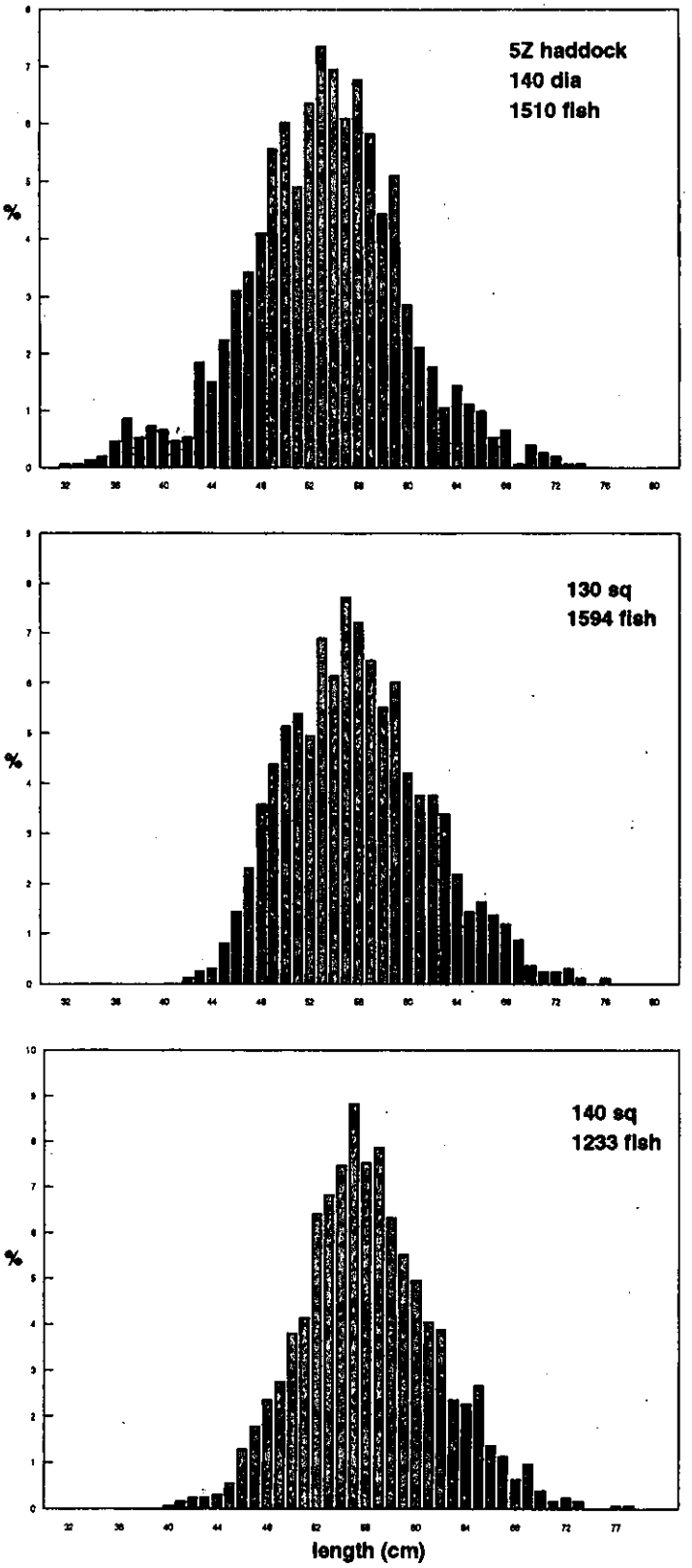

Figure 5: Length frequency distribution for 5Z haddock; commercial fishery using 140mm diamond, 130 square, and 140mm square mesh OTB gear.

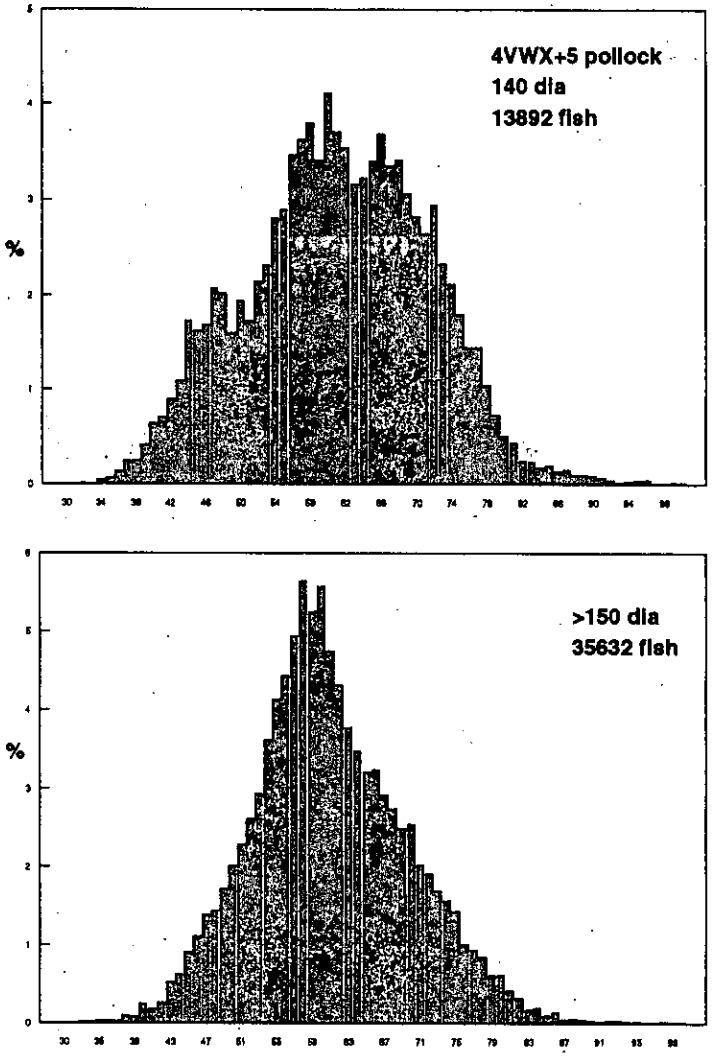

Figure 6: Length frequency distribution for 4VWX+5 pollock; commercial fishery using 140mm diamond, >150mm diamond, and 140mm square mesh OTB gear.

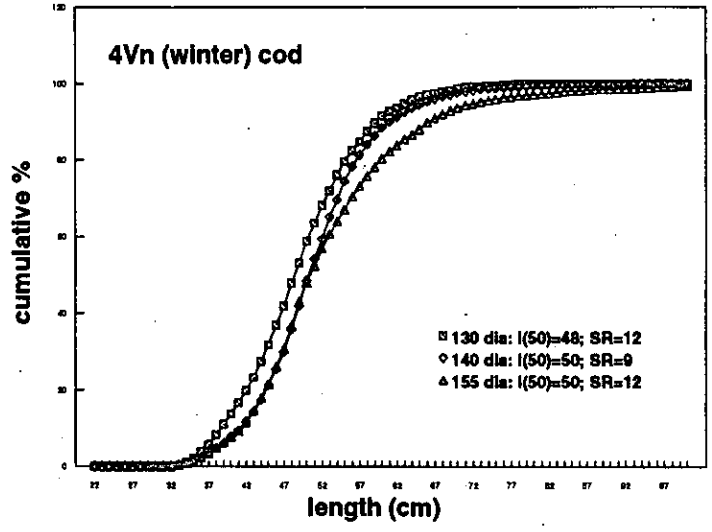

Figure 7: Cumulative percent ogive for 4Vn (winter) cod; commercial fishery using 130mm diamond, 140mm diamond, and >150mm diamond mesh OTB gear.

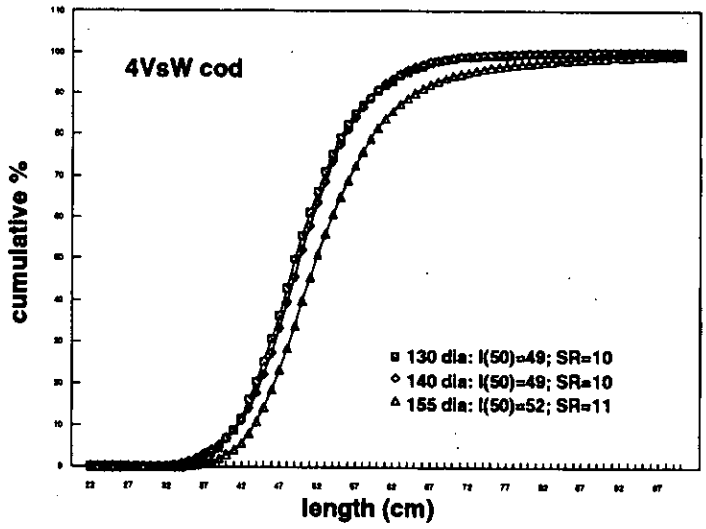

Figure 8: Cumulative percent ogive for 4VsW cod; commercial fishery using 130mm diamond, 140mm diamond, and >150mm diamond mesh OTB gear.

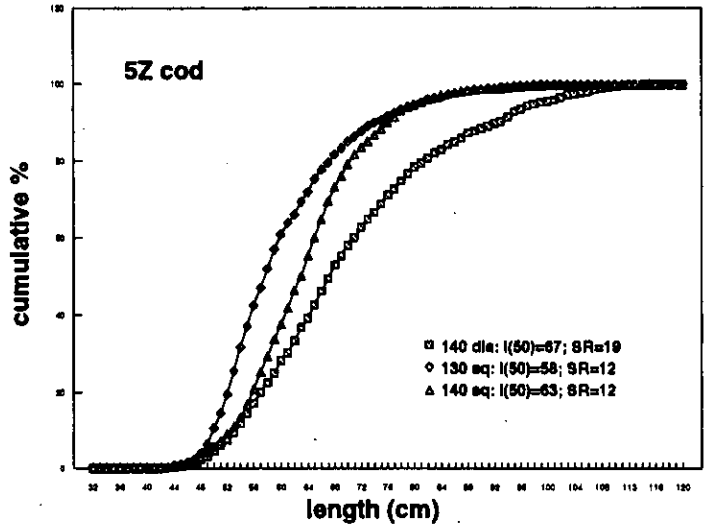

Figure 9: Cumulative percent ogive for 5Z cod; commercial fishery using 140mm diamond, 130mm square, and 140mm square mesh OTB gear.

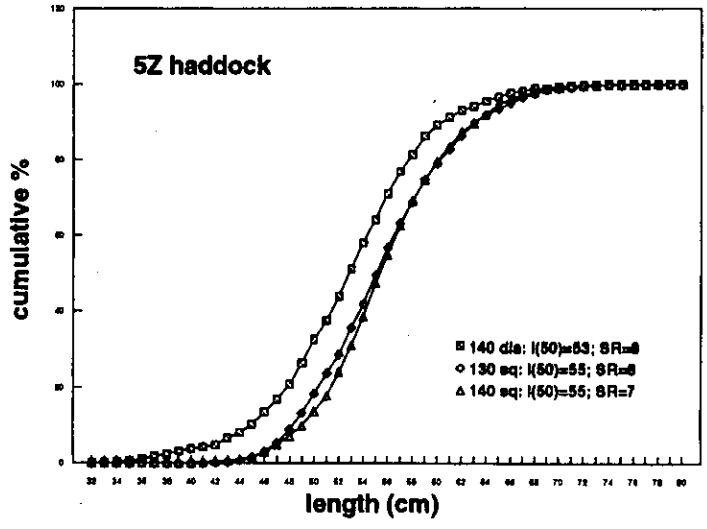

Figure 10: Cumulative percent ogive for 5Z haddock; commercial fishery using 140mm diamond, 130mm square, and 140mm square mesh OTB gear.

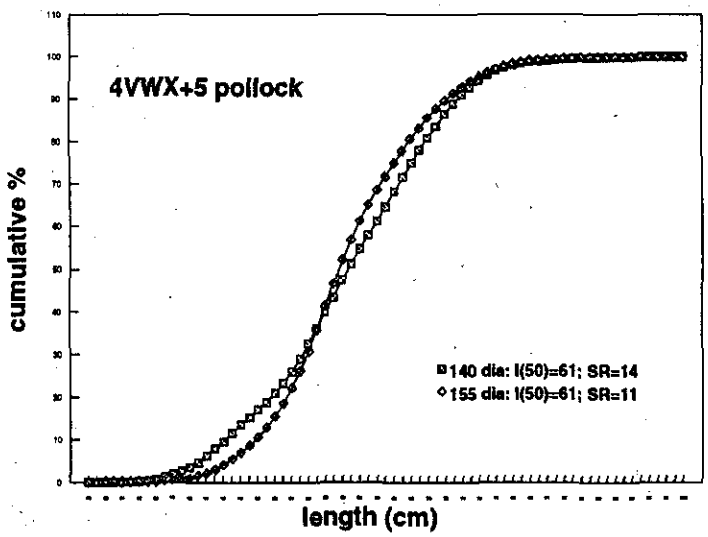

Figure 11: Cumulative percent ogive for 4VWX+5 pollock; commercial fishery using 140mm diamond, and 150+mm diamond mesh OTB gear.

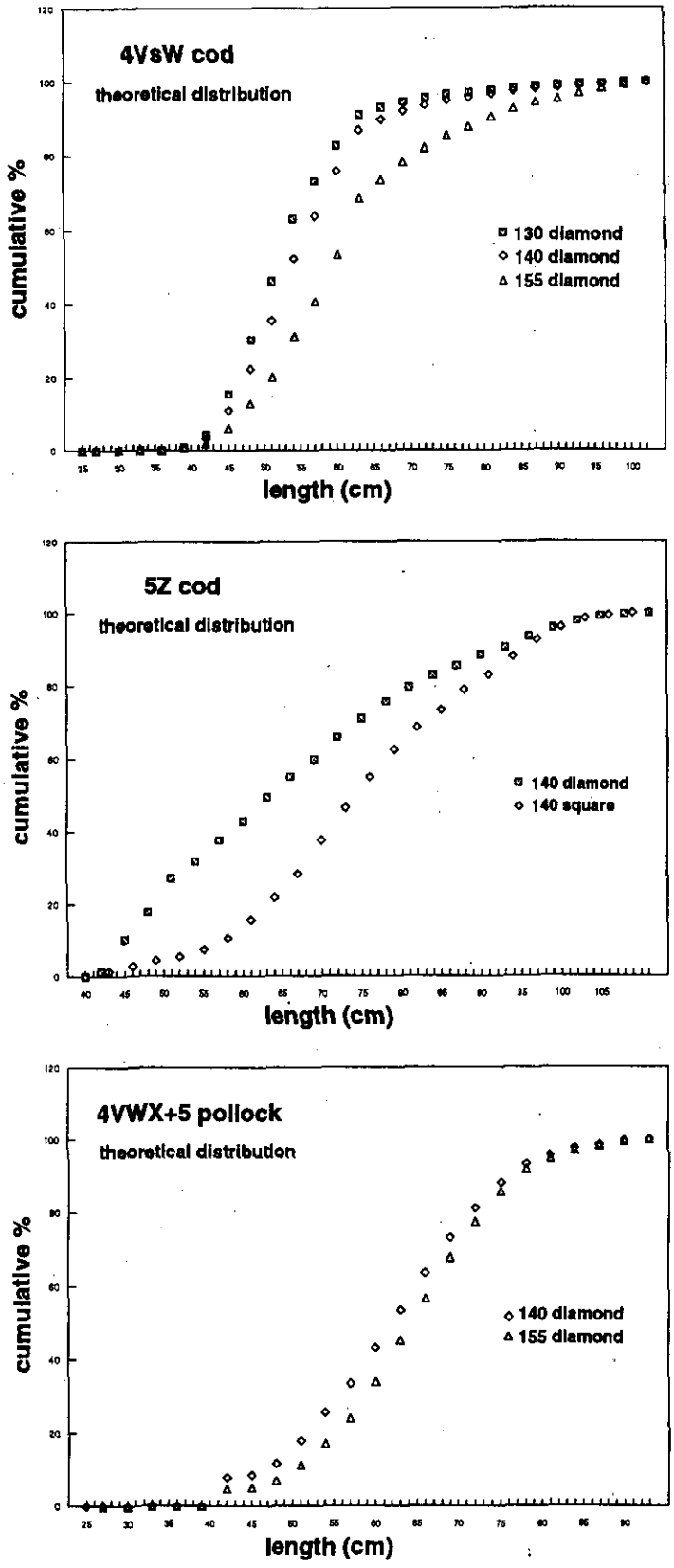

Figure 12: Theoretical catch numbers at length for 1991 4VsW cod, 5Z cod, and 4VWX+5 pollock, calculated from population numbers from SPA and mesh retention proportions at length.

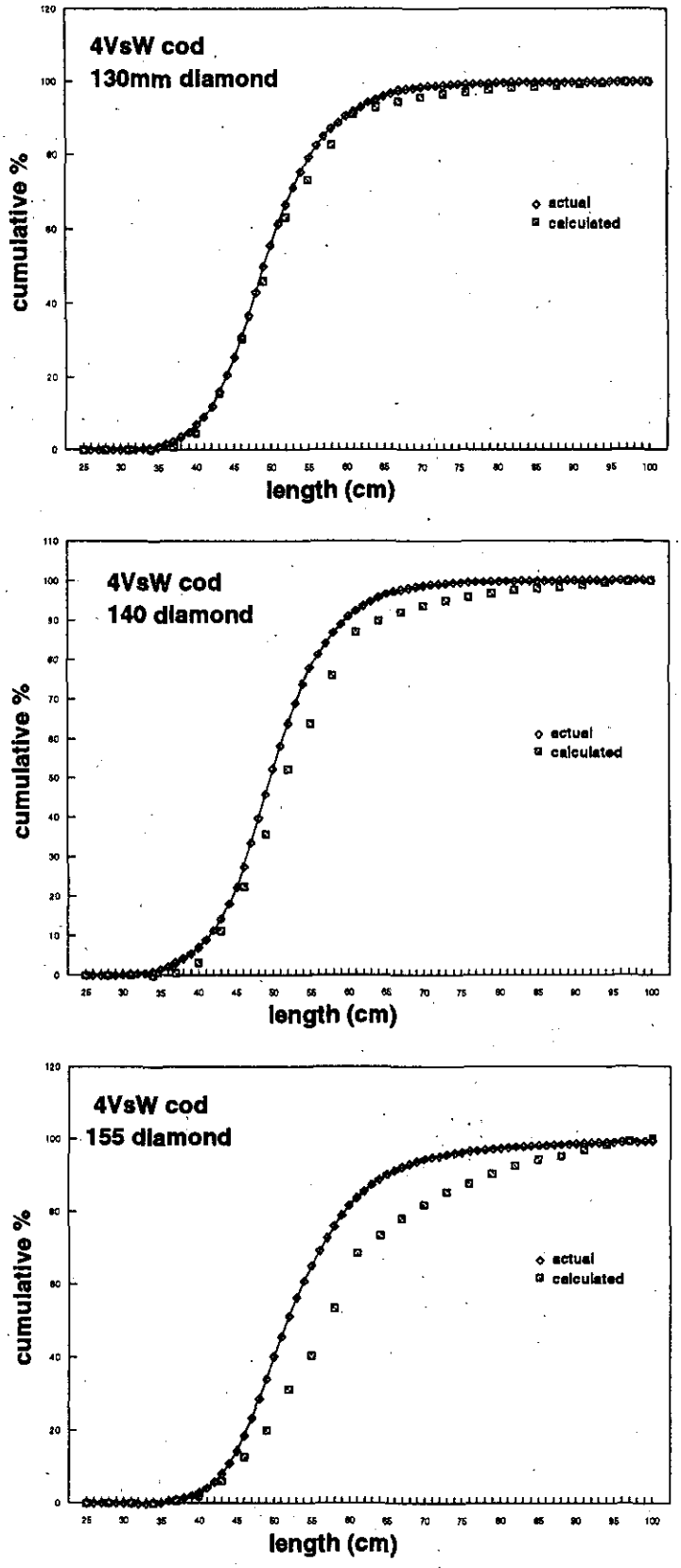

Figure 13: Cumulative percentage ogives, comparing calculated theoretical catch numbers against observed for 4VsW cod in 1991.

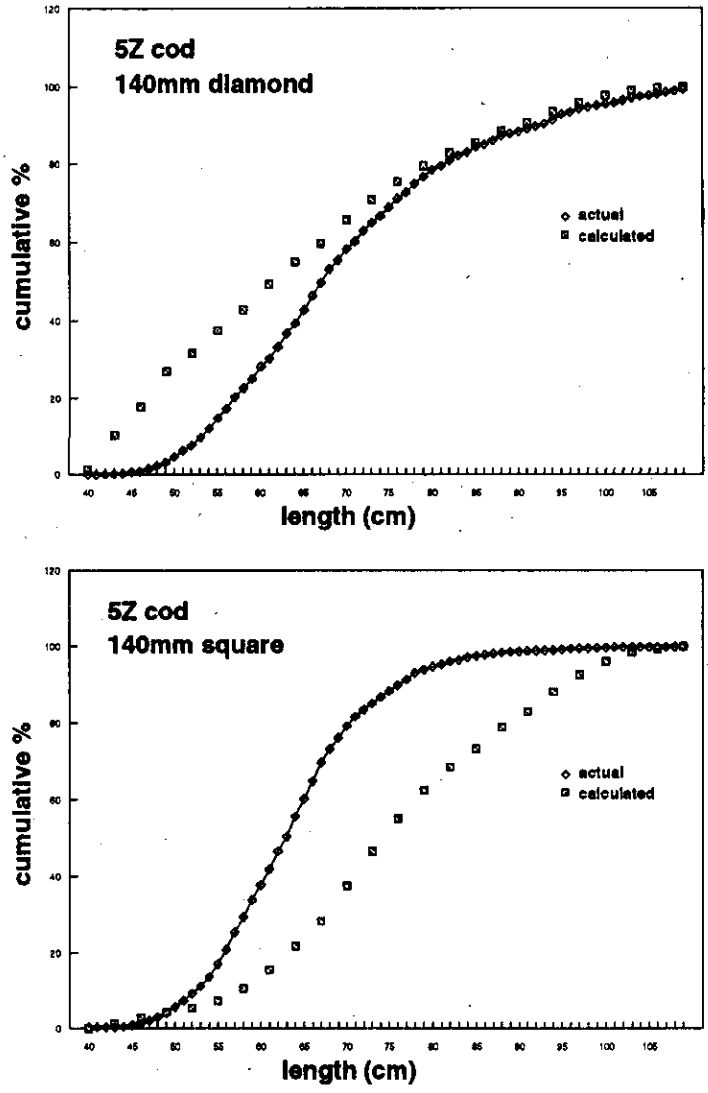

Figure 14: Cumulative percentage ogives, comparing calculated theoretical catch numbers against observed for 5Z cod in 1991.

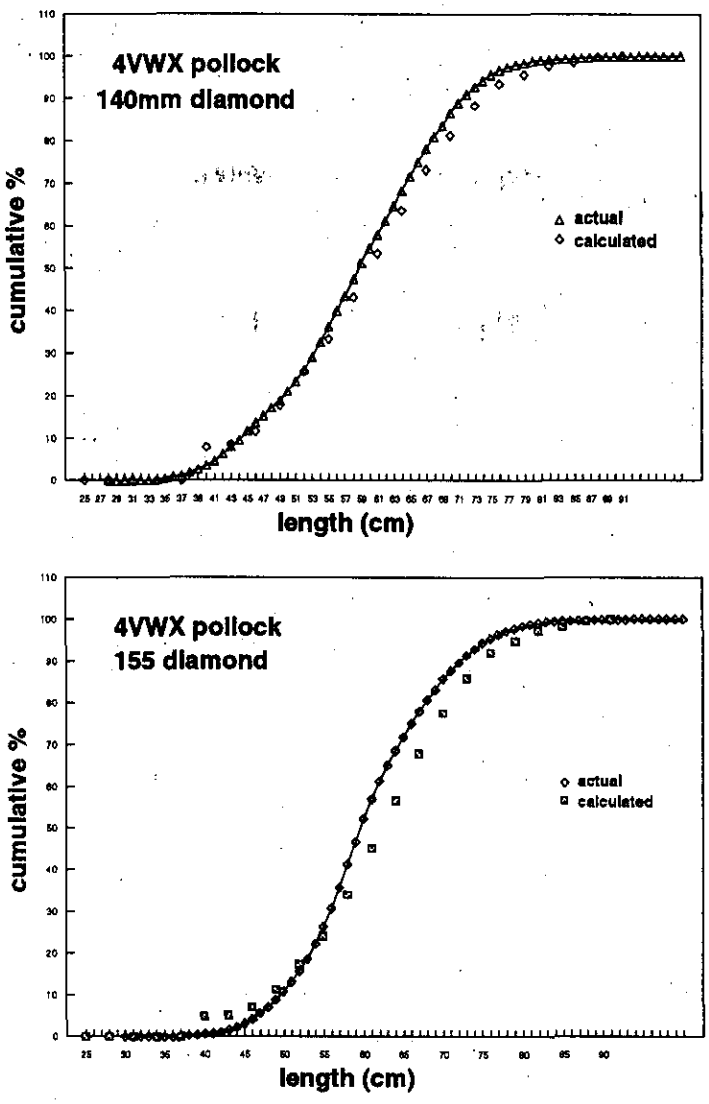

Figure 15: Cumulative percentage ogives, comparing calculated theoretical catch numbers against observed for 4VWX+5 pollock in 1991.

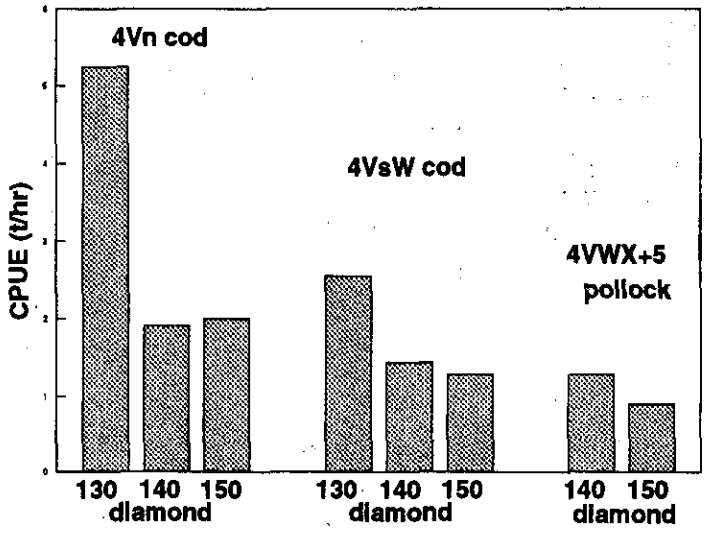

Figure 16: CPUE (tons/hr) observed in 4Vn cod, 4VWS cod, and 4VWX+5 pollock directed fisheries. Data are grouped by mesh size.

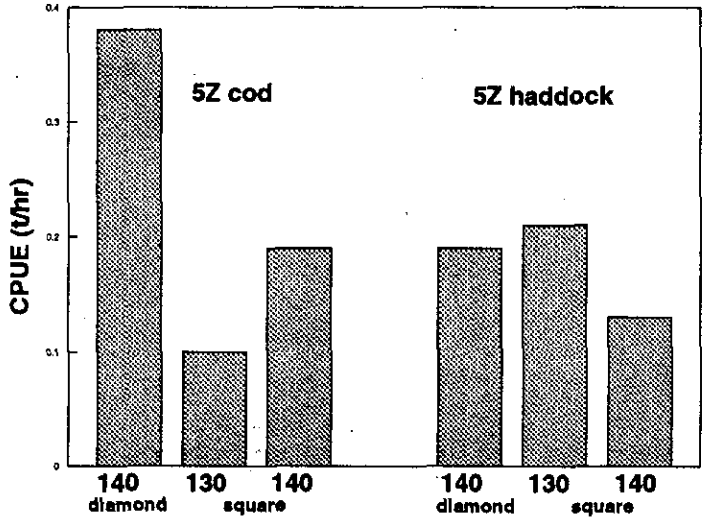

Figure 17: CPUE (tons/hr) observed in 5Z cod and haddock directed fisheries. Data are grouped by mesh size and type.