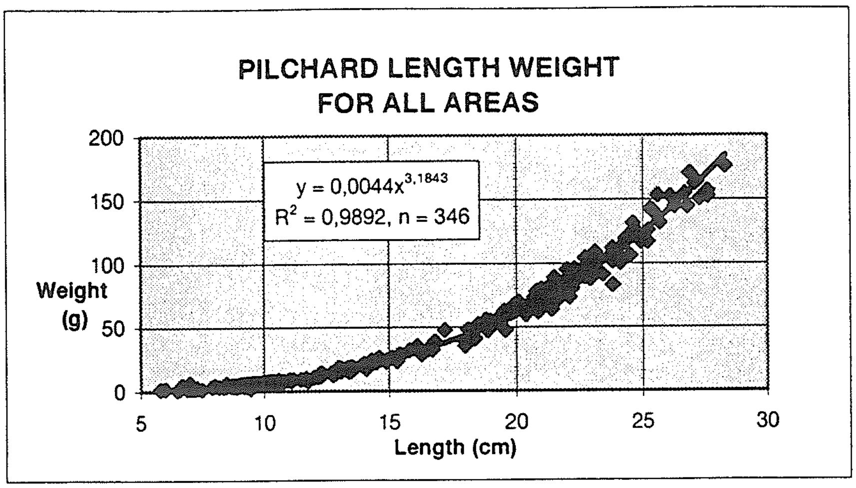
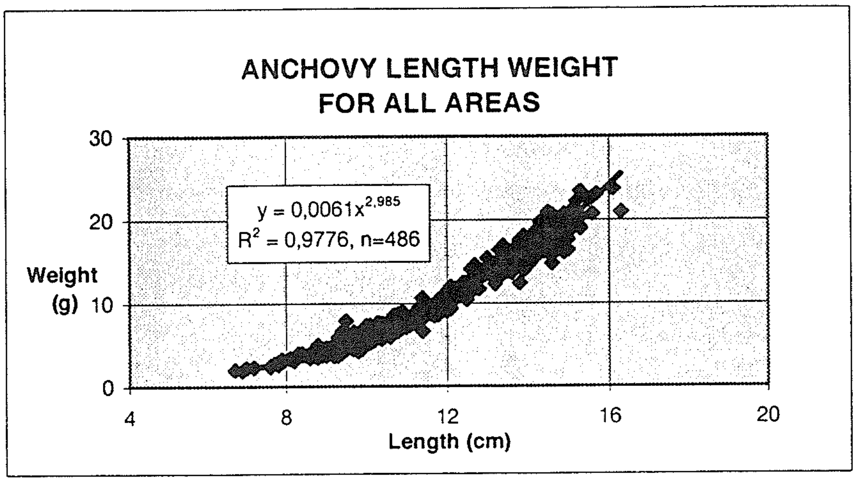
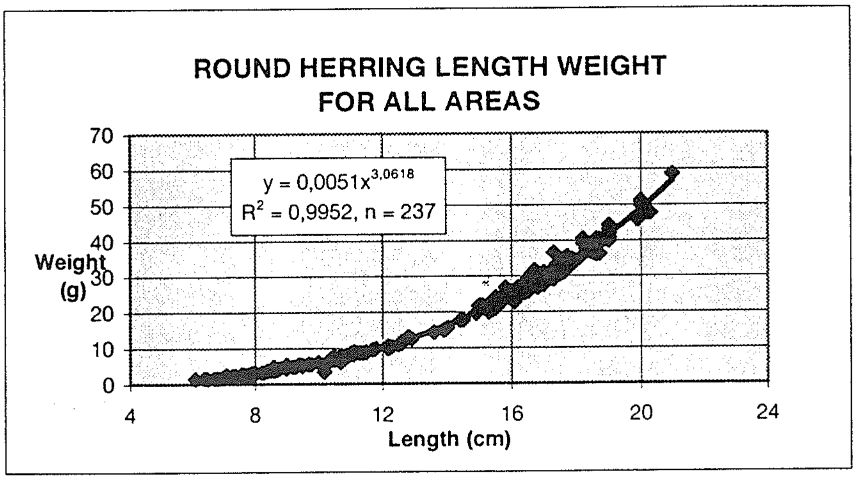
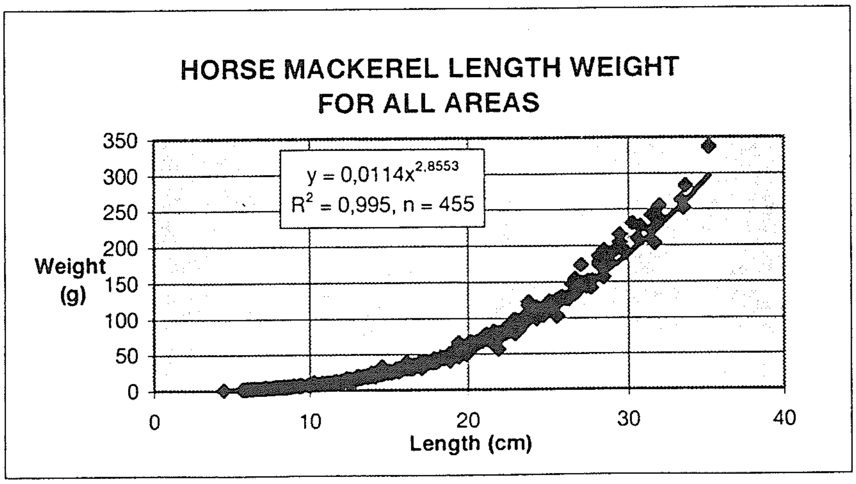
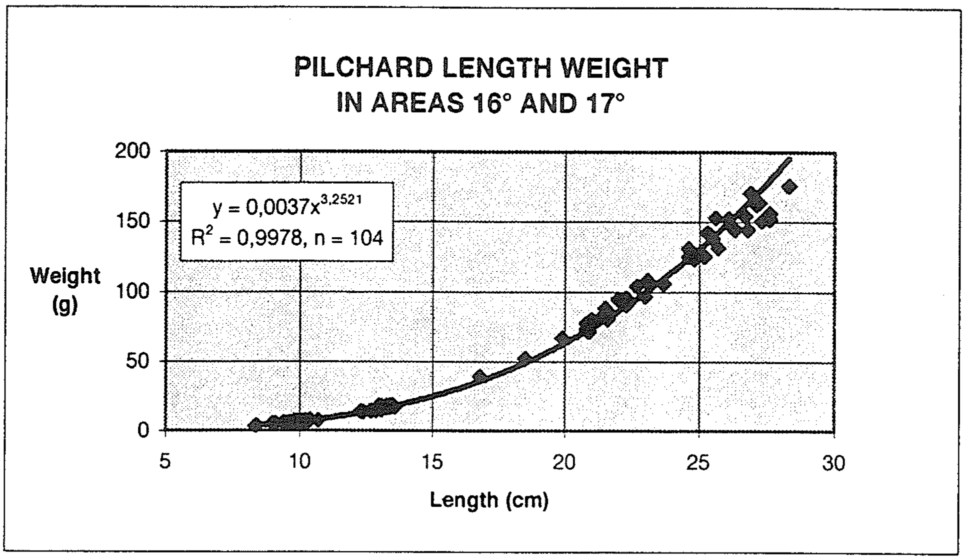
Annex VII Length-weight relations

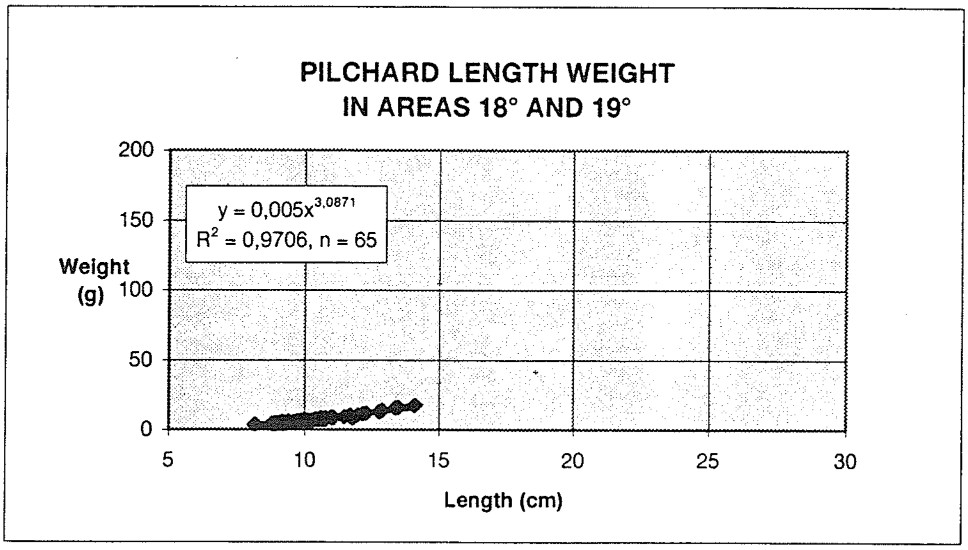


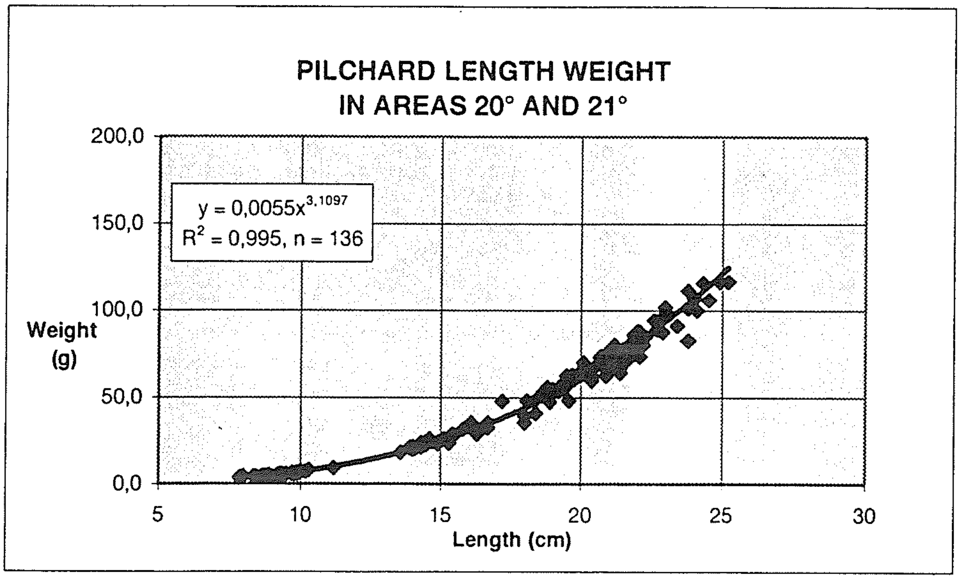


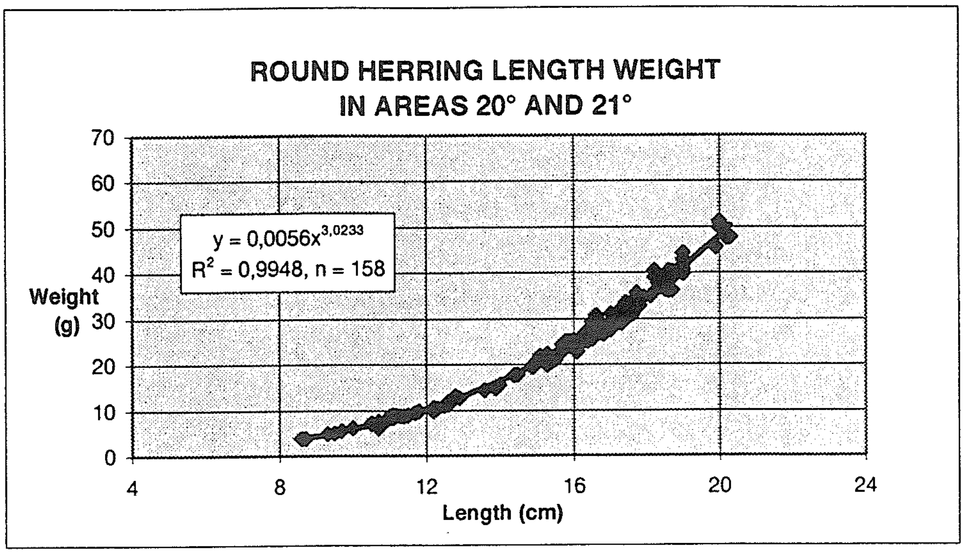


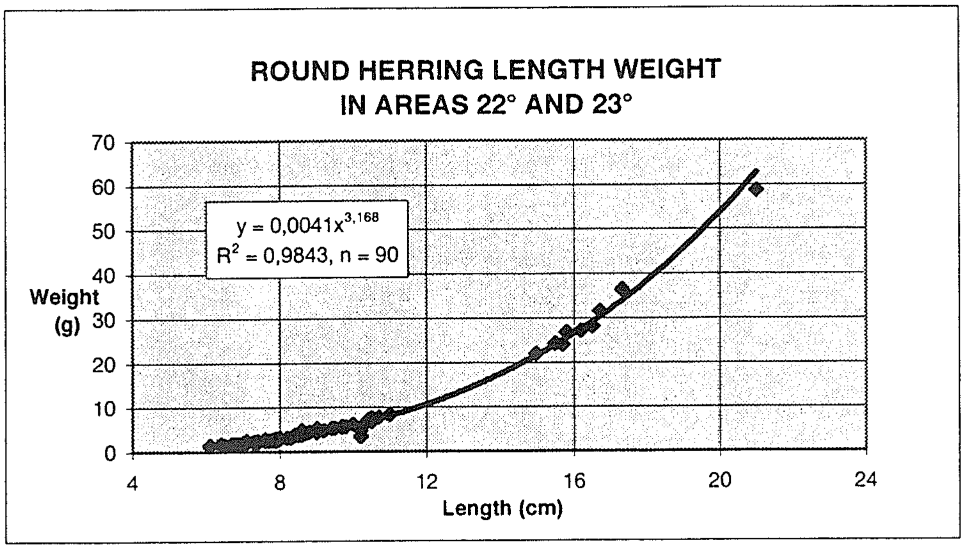


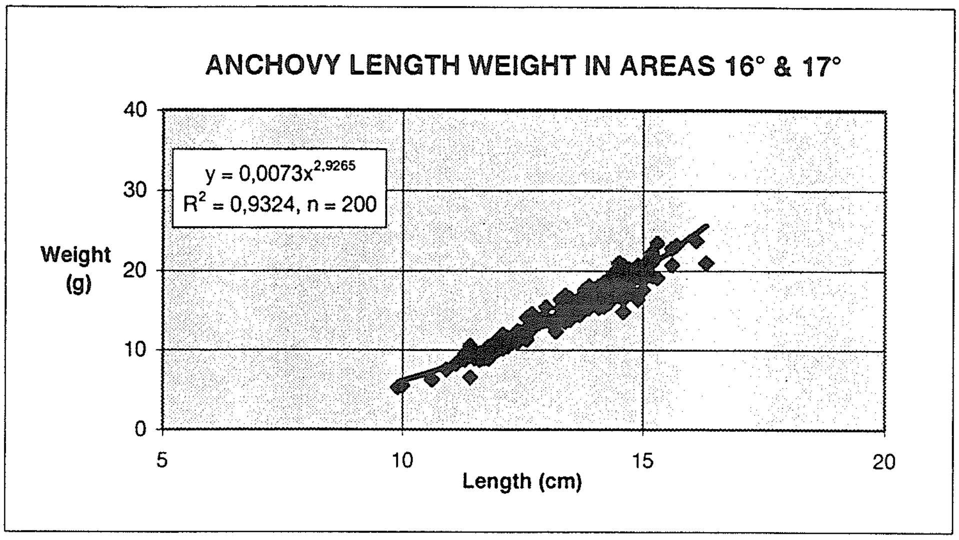

PILCHARD LENGTH WEIGHT
IN AREAS 16° AND 17°
y = 0,0037x^3,2521
R² = 0,9978, n = 104
Weight (g)
200
150
100
50
0
5
10
15
20
25
30
Length (cm)

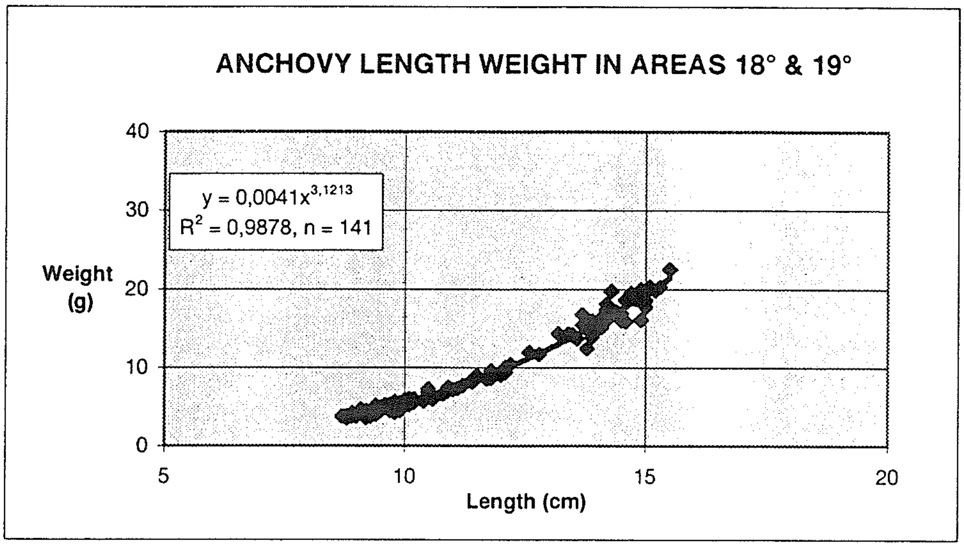

PILCHARD LENGTH WEIGHT
IN AREAS 18° AND 19°
y = 0,005x^3,0871
R² = 0,9706, n = 65
Weight (g)
200
150
100
50
0
5
10
15
20
25
30
Length (cm)

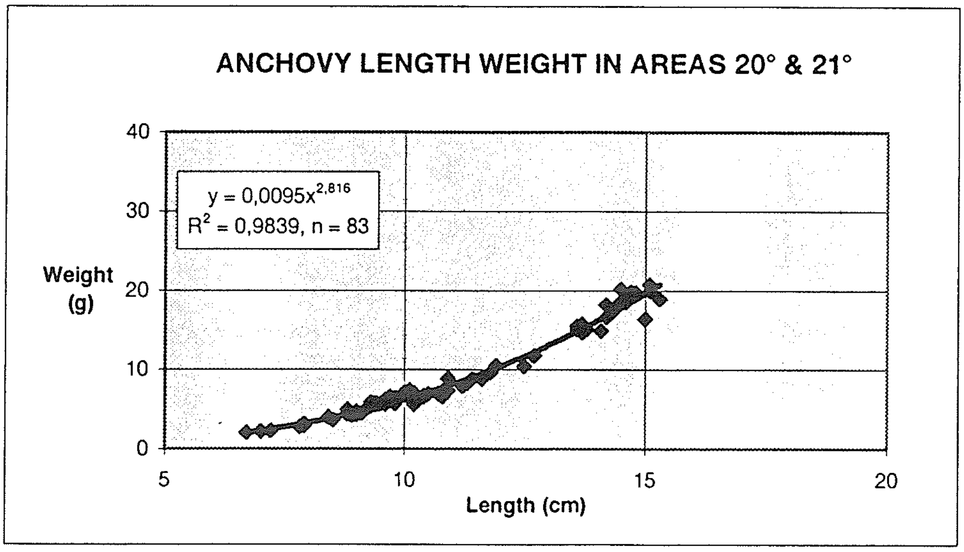

PILCHARD LENGTH WEIGHT
IN AREAS 20° AND 21°
y = 0,0055x^3,1097
R² = 0,995, n = 136
Weight (g)
200,0
150,0
100,0
50,0
0,0
5
10
15
20
25
30
Length (cm)

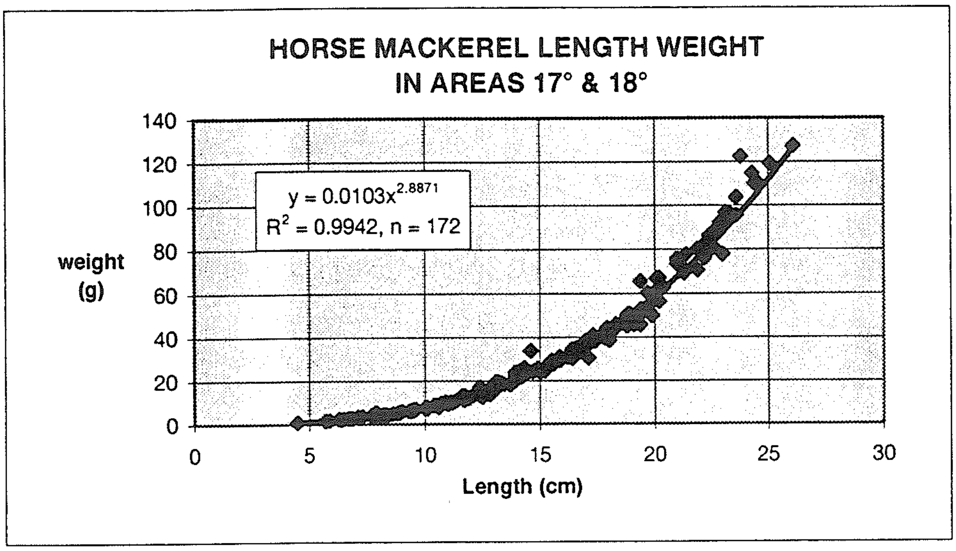

ROUND HERRING LENGTH WEIGHT
IN AREAS 20° AND 21°
y = 0,0056x^3,0233
R^2 = 0,9948, n = 158
Weight (g)
0
10
20
30
40
50
60
70
Length (cm)
4
8
12
16
20
24

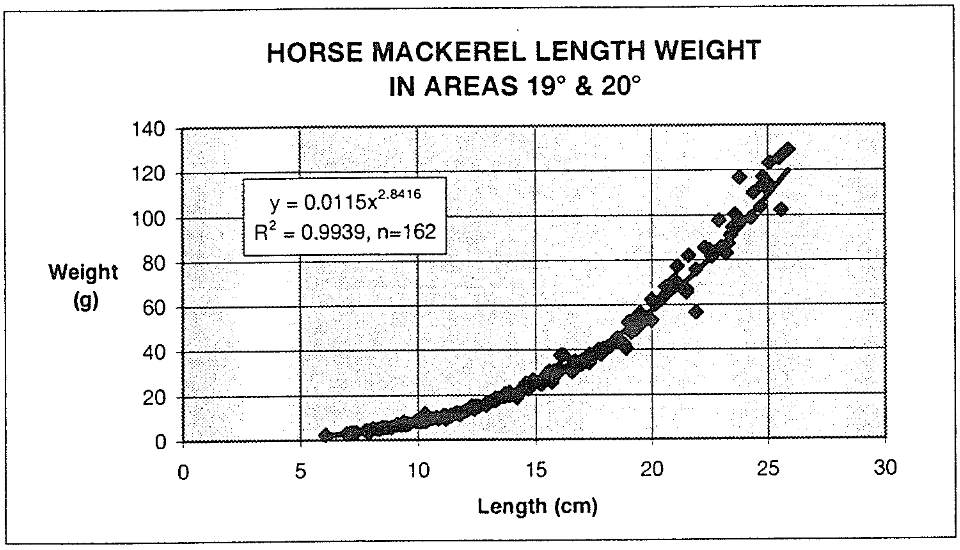

ROUND HERRING LENGTH WEIGHT
IN AREAS 22° AND 23°
y = 0,0041x^3,168
R^2 = 0,9843, n = 90
Weight (g)
0
10
20
30
40
50
60
70
Length (cm)
4
8
12
16
20
24

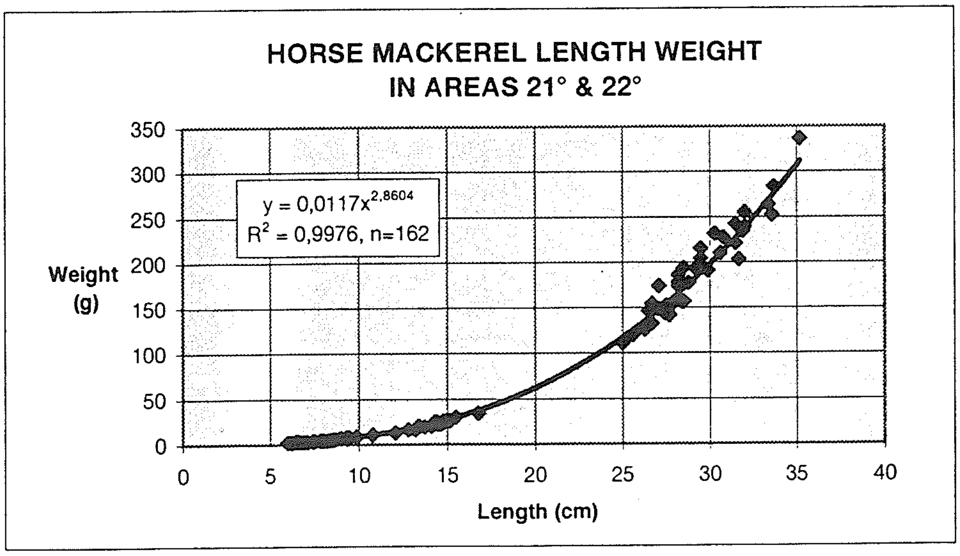

ANCHOVY LENGTH WEIGHT IN AREAS 16° & 17°
y = 0,0073x^2,9265
R^2 = 0,9324, n = 200
Weight (g)
40
30
20
10
0
5
10
15
20
Length (cm)


ANCHOVY LENGTH WEIGHT IN AREAS 18° & 19°
y = 0,0041x^3,1213
R^2 = 0,9878, n = 141
Weight (g)
40
30
20
10
0
5
10
15
20
Length (cm)


ANCHOVY LENGTH WEIGHT IN AREAS 20° & 21°
y = 0,0095x^2,816
R^2 = 0,9839, n = 83
Weight (g)
40
30
20
10
0
5
10
15
20
Length (cm)


HORSE MACKEREL LENGTH WEIGHT
IN AREAS 17° & 18°
y = 0.0103x^2.8871
R^2 = 0.9942, n = 172
weight (g)
0
20
40
60
80
100
120
140
Length (cm)
0
5
10
15
20
25
30


HORSE MACKEREL LENGTH WEIGHT
IN AREAS 19° & 20°
y = 0.0115x^2.8416
R^2 = 0.9939, n=162
Weight (g)
0
20
40
60
80
100
120
140
Length (cm)
0
5
10
15
20
25
30


HORSE MACKEREL LENGTH WEIGHT
IN AREAS 21° & 22°
y = 0,0117x^2,8604
R^2 = 0,9976, n=162
Weight (g)
0
50
100
150
200
250
300
350
Length (cm)
0
5
10
15
20
25
30
35
40

Annex VIII Reproductive status

PILCHARD BIOLOGICAL DATA

16° - 17°S

Length Class	*n*	*Mean*	*Sex*	*% per Maturity Stage*					*Mean Gonad*
		Weight	*Ratio*	*1*	*2*	*3*	*4*	*5*	*Weight*
14,0 - 19,9	insufficient number of observations								
19,0 - 19,9	12	60,64	0,67	25	50	25			1,38
20,0 - 20,9	13	70,93	0,46	38	16	23	15	8	1,11
21,0 -21,9	20	80,45	0,60	45	40	10	5		1,15
22,0 - 22,9	20	90,47	0,60	10	15	30	30	15	2,19
23,0 - 23,9	20	102,35	0,65	5	5	30	35	25	3,04
24,0 - 24,9	11	115,28	0,36		18	36	36	9	3,43
25,0 - 28,9	insufficient number of observations								

20° - 21°S

Length Class	*n*	*Mean*	*Sex*	*% per Maturity Stage*					*Mean Gonad*
		Weight	*Ratio*	*1*	*2*	*3*	*4*	*5*	*Weight*
14,0 - 14,9	11	22,50	0,70	91		9			0,03
15,0 - 18,9	insufficient number of observations								
19,0 - 19,9	10	55,62	0,80	30	50	10	10		1,31
20,0 - 20,9	15	66,37	0,73	33	33	33			0,87
21,0 -21,9	15	74,95	0,53	13	47	20	7	13	1,14
22,0 - 22,9	11	85,00	0,36	9	27	18	18	27	1,41
23,0 - 25,9	insufficient number of observations								

ANCHOVY BIOLOGICAL DATA

16° - 17°S

Length Class	*n*	*Mean Weight*	*Sex Ratio*	*% per Maturity Stage* 1	2	3	4	5	*Mean Gonad Weight*
10,0 - 10,9	insufficient number of observations								
11,0 - 11,9	14	9,10	0,80	100					0,00
12,0 - 12,9	18	12,08	0,50	72	17	11			0,08
13,0 - 13,9	20	15,22	0,40	65	20	15			0,12
14,0 - 14,9	20	17,56	0,18	70	15	15			0,14
15,0 - 15,9	13	20,65	0,30	54	15	31			0,25
16,0 - 16,9	insufficient number of observations								

18° - 19°S

Length Class	*n*	*Mean Weight*	*Sex Ratio*	*% per Maturity Stage* 1	2	3	4	5	*Mean Gonad Weight*
10,0 - 12,9	insufficient number of observations								
13,0 - 13,9	13	14,87	0,62	92	8				0,02
14,0 - 14,9	20	17,50	0,33	100					0,06
15,0 - 15,9	11	19,63	0,30	73	27				0,13
16,0 - 16,9	insufficient number of observations								

20° - 21°S

Length Class	*n*	*Mean Weight*	*Sex Ratio*	*% per Maturity Stage* 1	2	3	4	5	*Mean Gonad Weight*
10,0 - 10,9	11	6,59	-	100					
11,0 - 11,9	insufficient number of observations								
14,0 - 14,9	12	18,14	0,08	17	42	25		16	0,14
15,0 - 16,9	insufficient number of observations								

Annex IX Fish condition factor

Pilchard condition per area: number of samples (n), mean, variance (s^2), and standard deviation (s).

Area	*n*	*mean condition factor*	s^2	*s*
16° - 17°	138	0,803	0,0028	0,053
20° - 21°	100	0,747	0,0023	0,048

Anchovy condition per area: number of samples (n), mean, variance (s^2), and standard deviation (s).

Area	*n*	*mean condition factor*	s^2	*s*
16° - 17°	90	0,600	0,0022	0,0471
18° - 19°	62	0,572	0,0011	0,0338
20° - 21°	43	0,579	0,0020	0,0452

Analysis of variance (ANOVA) of pilchard condition per 2° latitude interval: degrees of freedom (df), sum of squares (SS), mean squares (MS), and F value (F_s).

Source of Variation	*df*	*SS*	*MS*	*Fs*
Among Areas	2	0,0324	0,01619	8,811**
16°-17°S vs 18°-19°S	1	0,0294	0,02940	15,999**
16°-17°S vs 20°-21°S	1	0,0128	0,01280	6,967*
18°-19°S vs 20°-21°S	1	0,0014	0,00136	0,741 (ns)
Within Areas	192	0,3528	0,00184	
Total	194	0,3852		

$F_{0,05(2,192)}=3,07$
$F_{0,01(2,192)}=4,79$

** = P <= 0,01
* = P <= 0,05
ns = not significant

See text for explanations

Annex X Results of intercalibration experiment

Intercalibration report

An intercalibration of the 38 kHz Simrad EK-500 echo sounder / integrator systems on the R/V Dr. Fridjof Nansen (57m, 2700HP), and R/V Welwitchia (47m ,1500HP), was conducted on June 8, 1994, from position 1745S 1138E to 1730S 1125E. The acoustic recordings mainly consisted of plankton and mesopelagic fish. The intercalibration was performed in the standard manner, (Foote et. al 1987), Nansen sailing 0.5 nautical miles in front and to the port of Welwitchia. Both echo sounder systems had recently been calibrated using standard targets according to Foote et al. (1987), adjusted to split beam systems after Nes (1991). The vessel log on the following vessel, Welwitchia, was adjusted to Nansen's log, ensuring pairwise outputs of the integrator, relative to ground.

Contributions from fish and plankton were integrated and averaged over one nautical miles in 8 pelagic channels covering the depth interval from 5 to 500 meters. The integrator output, s_A, varied from 1 to 22000 [m^2/nm^2] throughout the intercalibration. The threshold and color settings of the instruments were the same in the two vessels, Table 1, and depth layers were adjusted according to the relative draft of the transducer mountings on the vessels.

The echo recordings was after the intercalibration transferred to one of the vessels, and carefully scrutinized by the instrument chiefs on the two vessels in order to validate the datasets log by log, with the intention to remove miles where the acoustic recordings were different because of the horizontal distance between the vessels. A few nautical miles was removed because of obvious log differences after a 90 degree course change, and some because of air bubble attenuation on Welwichia. A total of 58 valid pairvise observations have been included in the comparison.

Fig.1 show the area backscattering coefficients recorded during the intercalibration, and Fig.2 show a regression on the two datasets, with 95% confidence belts for the regression line indicated. Forcing the regression through the origo 0,0 yields an estimate of the slope of 1.038, indicating that Welwitcia's values are slightly higher than Nansens. In a pairvise test, however, the difference is not significant (p=0.28). The observed difference is within the expected accuracy of the sphere calibration method, 0.1 dB.

Table 1 Settings of the echo sounder / echo integrators during the intercalibration.

Echo sounder setting	*R.V.Dr. Fridtjof Nansen*	*R.V.Velwitschia*	Comments
2 way beam angle	-21.0	-20.8	Spec. from Simrad
S_V Transducer gain	28.1	27.9	
TS Transducer gain	28.1	27.9	Does not affect integration
-3 dB beam angle	6.8	6.7	Does not affect integration
Offsets	0.00, 0.04	0.0, -0.01	Does not affect integration
Integrator threshold All channels	-80 dB SV	-80 dB SV	
SV colour minimum	-75 dB SV	-75 dB SV	

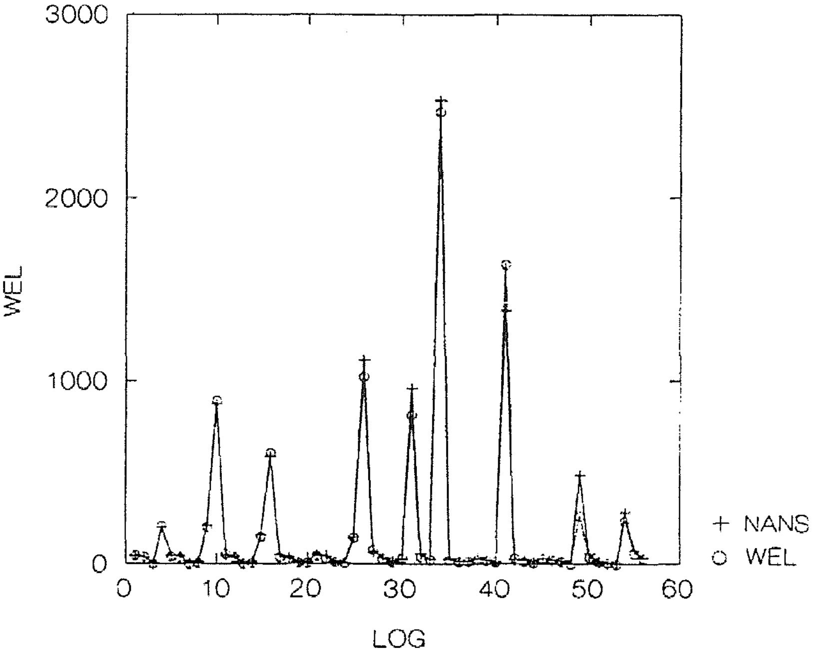


Fig.1. Area backscattering coefficients from R/V Dr. Fridjof Nansen and R/V Welwitchia during the intercalibration survey track. Two large values are omitted from the plot.

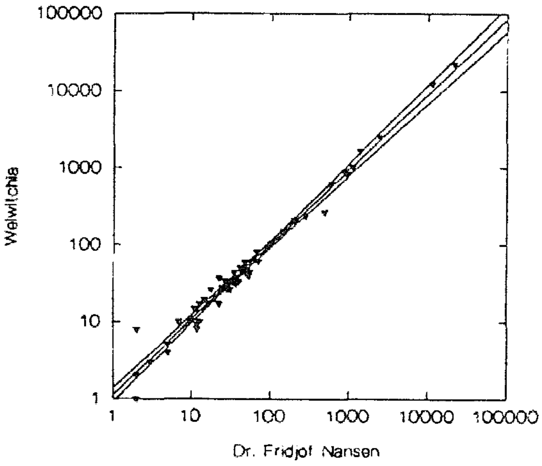
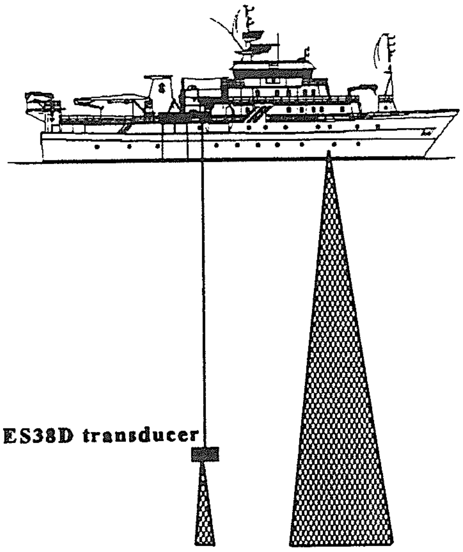


Fig.2. Linear regression between the area backscattering coefficients with 95% confidence belts indicated. Logarithmic scale.

Annex XI Additional experiments

In situ target strength measurements

Target strength measurements in situ was conducted on horse mackerel and hake using the split beam sonde, at depths up to 300 meters. The basic setup during these measurements is shown below:



TS sonde, R/V Dr. Fridjof Nansen

The main advantage with this system is its ability to resolve layers and shoals into single fish by reducing the pulse volume compared to the hull mounted transducer. This ensures a high signal to noise ratio for the target strength measurement, as well as reducing the probability for multiple target to be accepted as single targets. When sufficiently pure concentrations of fish occurred during the survey, 1–3 hours were spent on one TS–station, indicated in the station charts. High resolution target strength data on hake closer than one meter from the seabed was recorded at 300 m depth, and experiments on close bottom echo integration on single hake, 0.2–0.5 meters from the bottom was successfully conducted using the TS–sonde. The data will be analyzed and presented at a later stage.

School measurements with the SA–950 multibeam sonar

The Simrad SA–950 sonar was run during most of the survey. The sonar was connected to a HP–9000/712 computer, logging detected school data via the ethernet. The sonar was used in side looking mode, producing a hardcopy output of schools detected within 50–150 or 50–300 m starboard. All detected schools were measured by the school recognition software developed at IMR by Misund and Totland (1993), and stored to file for later analysis.

Quantitative measurements

The sonar was calibrated in Baía dos Tigres, Angola, using a target of 10 air filled, hard, plastic 11 inch diameter trawlfloats. One of these floats was measured to be –23.5 dB (SD=0.5 dB) using the 120 kHz split beam echo sounder. Having almost the same wavelength–to size ratio to the large–air filled target, it is reasonable to believe that the TS at 95 kHz is close to the target strength measured at 120 kHz. The total target of 10 should then be about TS=–23.5+10logn=–13.5 dB. Several passes were made, recording this target by the school recognition software. Within the recognition software a computation the target and approximate echo strength is made, simply by adding each colour pixel value (1–64) over the entire school area. This parameter, in the output files called count, could be calibrated to approximate absolute SV, using the measured TS of the calibration target.

Comparative measurements

From the vertical echo sounder, the average school size in an area is determined by echo integration. The echo sounder has a very low sampling volume at the depths where the bulk of the pilchard was recorded during the survey, 4–30 m, and the biomass estimate will be sensitive towards school avoidance reactions during the survey. Analysing the area density of schools detected by the sonar in the area covered to the starboard of the vessel, from 50–150 m, computations of comparative biomass estimates may be made using the previously computed average school size.

The data will be analyzed and presented later.

School measurements with the SA–950 multibeam sonar

The Simrad SA–950 sonar was run during most of the survey. The sonar was connected to a HP–9000/712 computer, logging detected school data via the ethernet. The sonar was used in side looking mode, producing a hardcopy output of schools detected within 50–150 or 50–300 m starboard. All detected schools were measured by the school recognition software developed at IMR by Misund and Totland (1993), and stored to file for later analysis.

Quantitative measurements

The sonar was calibrated in Baía dos Tigres, Angola, using a target of 10 air filled, hard, plastic 11 inch diameter trawlfloats. One of these floats was measured to be –23.5 dB (SD=0.5 dB) using the 120 kHz split beam echo sounder. Having almost the same wavelength–to size ratio to the large–air filled target, it is reasonable to believe that the TS at 95 kHz is close to the target strength measured at 120 kHz. The total target of 10 should then be about $TS=-23.5+10\log n=-13.5$ dB. Several passes were made, recording this target by the school recognition software. Within the recognition software a computation the target and approximate echo strength is made, simply by adding each colour pixel value (1–64) over the entire school area. This parameter, in the output files called count, could be calibrated to approximate absolute SV, using the measured TS of the calibration target.

Comparative measurements

From the vertical echo sounder, the average school size in an area is determined by echo integration. The echo sounder has a very low sampling volume at the depths where the bulk of the pilchard was recorded during the survey, 4–30 m, and the biomass estimate will be sensitive towards school avoidance reactions during the survey. Analysing the area density of schools detected by the sonar in the area covered to the starboard of the vessel, from 50–150 m, computations of comparative biomass estimates may be made using the previously computed average school size.

The data will be analyzed and presented later.

Trawl experiments

Experiments using the constraint technique on bottom trawl doors have been conducted using the 7.8 m^2 Tyborøn trawldoors on the Gisund Super bottom trawl, holding 40 m sweeps. The method is described by Engås & Ona (1991 and 1993).

A constant doorspread of about 52 m was achieved at all depths sampled, Figure 1, compared to a varying doorspread of 52–69 m, increasing with depth, when the trawl was shot without constraining rope between the warps. The results from the trials will be reported to the Catch Division, IMR.

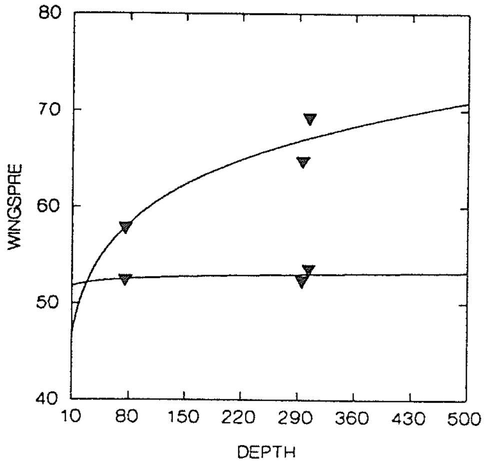


Figure 1 Door door spread as a function of depth for Gisund Super, Tyborøn doors.
Upper curve: normal spread
Lower curve: with constraining rope