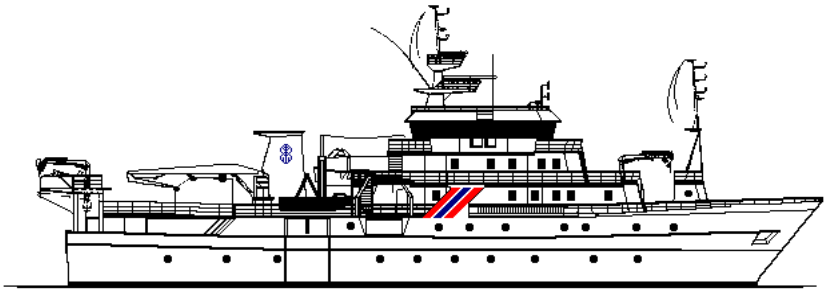
NORAD – FAO – TRAINING COURSE

"DR. FRIDTJOF NANSEN, 28 Oct. 2000"



FISHERIES ACOUSTICS
Training survey

Dakar, Senegal, Oct. 2000

NORAD /FAO

Institute of Marine Research
Bergen
Norway

CRUISE REPORTS "DR. FRIDTJOF NANSEN"

Training course survey

Cruise Report

ESTIMATION OF PELAGIC FISH BIOMASS IN SOUTH OFF DAKAR OCTOBER 24 – 27. 2000

by

Egil Ona [1], Ingvald Svellingen [1,] Mostafa Chbani Idrissi [2], Hassan Moustahfid [2] ,Ebaya Ould Mohamed Mahmoud [3], , Hamid Chfiri [2], Ibrahima Sow [4], Abdoulaye Sarre [4], Madiabel Diop [4], Mamadou Sane [4], Asbeer Mendy [5], Ousman Mass Diop [5], Ely Ould Sidi Ould Beibou [3], Sall Mamadou Diallo [3],

1. Institute of Marine Research, P. O. Box 1870 Nordnes, N-5817 Bergen, Norway
2. Institut National de Recherches Halieutiques, 2 Rue Tiznit , Casablanca, Maroc
3. Centre National de Recherches Oceanographiques et des Peches, Mauritanie
4. Centre de Recherches Oceanographiques de Dakar Thiaroye, Senegal
5. Fisheries Department, The Gambia

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

As the last part of the Training course in Fisheries Acoustic, a training survey was conducted on the shelf in Senegal, south of Dakar. The scientific staff was spilt into two survey groups, each with a cruise leader. These were responsible, together with their groups, to perform a full calibration of the vessel at a fixed location, 14 38,3N, 17 18,6 W. The survey started with calibration at Dakar Oct. 24.10.00 at 1200 h, to 25.10.00 at 1200 h, when the acoustic surveying was started. The abundance estimation of pelagic fish on the shelf was conducted according to standard acoustic methodology between 25. 10 – 27.10.00, for about 48 hours.

1.2 OBJECTIVES OF THE SURVEY

The overall survey objective were:

- To carry out a full calibration for target strength measurements and for echo integration by two teams in serial
- To measure the pelagic abundance of fish on the shelf area south of Dakar, limited between Latitudes $13^{0}30'$N and $14^{0}30'$, and the 20 and 200 m depth isobaths. Scrutinising categories were: Sardinellas, Horse Mackerel, Pelagic 2 (mixed), Plankton and Other demersals.

1.3 PARTICIPATION

The scientific staff consisted of:

From Morocco:
24/10/00 – 28/10/00 Mostafa Chbani Idrissi (cruise leader Team 1), Hassan Moustahfid, Hamid Chfiri.

From Gambia:
24/10/00 – 28/10/00 Asberr N:Mendy, Ousman Mass Jobe.

From Senegal:
24/10/00 – 28/10/00 Ibrahima Sow, Abdoulaye Sarre, Madiabel Diop, Sané Mamadou.

From Mauritania:
24/10/00 – 28/10/00 Ebaya Ould Mohamed Mahmoud (cruise leader Team 2), Ely Ould Sidi Ould Beibou, Sall Mamadou diallo.

FAO Consultants:
24/10/00 – 28/10/00 Egil Ona, Ingvald Svellingen; Birane Samb.

1.4 Narrative

Started at Oct. 25 at 12 h, The survey began by planning a systematic parallel transect survey, with transects spaced at about 7 nautical miles apart, covering the area between the 20 m to the 200 m depth isobaths. This was done in order to cover the distribution of the pelagic fish resources of the shelf lying within Latitude 13°30' N to 14° 30', mainly concentrated for the Sardinellas *(Sardinella aurita* and *Sardinella maderensis*). The survey effort was evenly spread in the investigation area.

After the calibration exercise, it was intended to carry out irregular trawls to either separate/confirm echo registrations or to check for species mix from the very start of the survey. However this was only possible on the Gambian side, while trawls in Senegalese waters were delayed until a proper fishery Licence was received from Senegalese Ministry. The Licence was received at morning 26.10.2000 and two trawl hauls in the waters of Senegal were conducted. The survey was finalized Oct. 27. at 06 h. Dakar was reached at Oct. 27. at 10 h.

CHAPITRE 2 METHODS

2.1. Survey area

The survey area covers north of the Gambia, Latitude 13° 30'N to its Northern border with Senegal and proceeded to Latitude 14°30', starting from the 20 m to the 200 m depth contour. Thus, the cruise (pelagic survey) covered an area of approximately **1800 nmi^2** (Fig. 1). The area was chosen on the basis of prior information regarding the distribution of pelagic fish in this sub-region received. It is believed to be a rich fishing ground due to its location within the two rivers, River Saloum and the River Gambia. The survey track is reproduced in Figure 1.

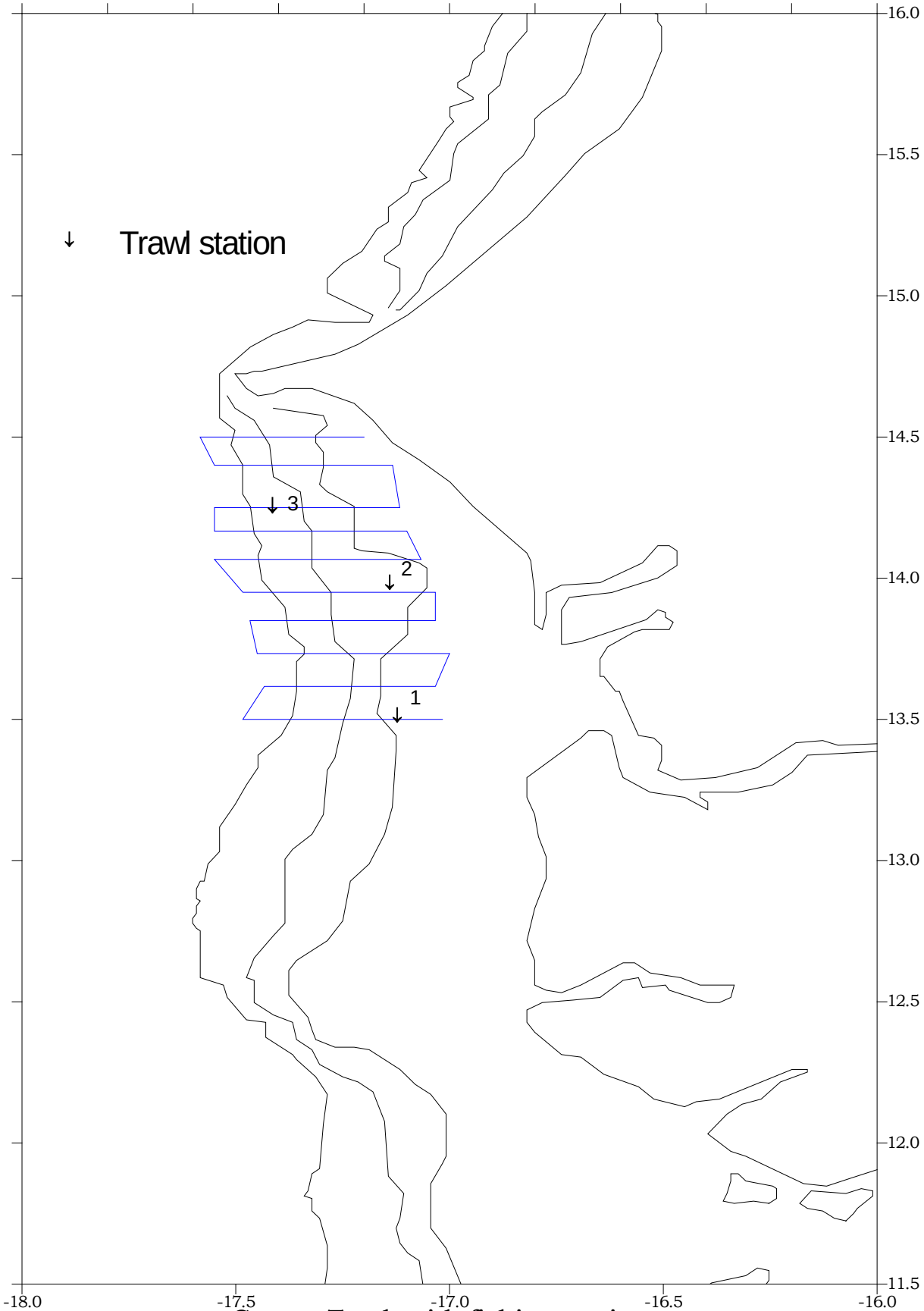
2.2. Calibration data

A calibration exercise, with several repeated calibrations of the 38 kHz transducer was carried out according to standard procedures (Foote et al. 1987), using the 60 mm CU (copper sphere) with an estimated TS of –33.6 dB at the recorded sound velocity,1535 m/s (25.5 C°, 35 °/$_{oo}$ S). Full calibration of the TS transducer gain and beam pattern using the LOBE software, (Simrad A/S) was conducted several times, as well as calibration of the S_v Tranducer gain, with integration of the sphere echo at acoustic axis. Detailes of the settings and calibration results are found in ANNEX I.

2.3. Trawl sampling

As previously mentioned, trawls were hauled for biological sampling purposes and identification. Either pelagic trawl with floats were used or demersal trawls fitted with floats in shallow waters (depth less than 25 m) areas. A detailed description of the equipment and gear used in several Nansen reports, and will not be repeated here. The trawl hauls are

sampled for composition and numbers of each species caught. Species identification was based on FAO Species Guides. Length frequency distributions, by total fish length in cm, of target species (Sardinellas, Trachurus sp.). were done in stations where they were present. Details from the trawl catches are given in ANNEX II.



Course Track with fishing stations.

II. Biological parameters, like length, weight, root mean square length and length /weight relationships for the target species were computed in Excel.

2.4 Acoustic Sampling

A SIMRAD EK500 echo sounder was used and the echograms were stored on both paper and files. The acoustic biomass estimates were based on the echo integration technique. The Bergen Echo Integrator (BEI) was used for analysis and allocation of the integrated echo energy, s_A-values (mean area back scattering coefficient in [m^2/n.mi^2], "NASC") to the individual specified target groups by 1 nmi intervals. Depth resolution was 20 m channels in the pelagic region, and 2 m in the bottom region. The splitting and allocation of the integrator energy (s_A-values) was based on a combination of a visual scrutiny of the behaviour pattern as deduced from echo diagrams, the BEI analysis, and the catch compositions.
("NASC", Nautical Area Scattering Coefficient, ICES FAST working group suggestion for new definition)

2.5 Biological Sampling

Biological sampling of the fish was carried out using trawls. A small pelagic trawl with floats was used. A larger pelagic trawl and the bottom trawl was also available but not used for sampling the pelagic fish in very shallow waters (depth less than 25 m). ANNEX III gives a description of the instruments and the fishing gear used. All catches were sampled for composition by weight and numbers of each species caught. Length frequency distributions, by total fish length in cm of the selected target species were taken in all the stations where they were present.

The following target groups were used for the survey:
1) Sardinellas (flat sardinella *Sardinella maderensis* and round sardinella *S. aurita*),
2) Horse mackerels (Cunene horse mackerel *T. trecae*),
3) Mackerels (chub mackerel *Scomber japonicus*),
4) Other pelagic scombrids, carangids and associated species
5) Other demersal species (such as Sparidae, Haemulidae and Merluccidae).

2.6 Biomass estimates

For our purposes, the following target strength (TS) function was applied to convert allocated s_A-values (average integrator value, or area back scattering coefficient for a given species or group of species in a specified area) to number of fish:

For $\mathbf{TS = 20 \log L_{RMSL} - 71{,}9\ dB}$ (1)

With $\mathbf{L_{RMSL} = \sqrt{\Sigma n_i L_i^2 / \Sigma n_i}}$

The calculations could be simplified by computing

$$\mathbf{\langle \sigma \rangle = 4 \pi . 10^{TS/10}} \quad (2)$$

The area density in numbers/nm^2 of a particular length group, i ,is calculated from the formula:

$$\rho i = \frac{s_A}{\langle \sigma \rangle} \quad (3)$$

Where ρ_i= density (/NM^2) of fish in length group *i*

s_A = mean area backscattering coefficient a species within an aggregation area, in m^2/n.mi^2

n_i = frequency count of length group *i* in a pooled representative sample from the distribution area.

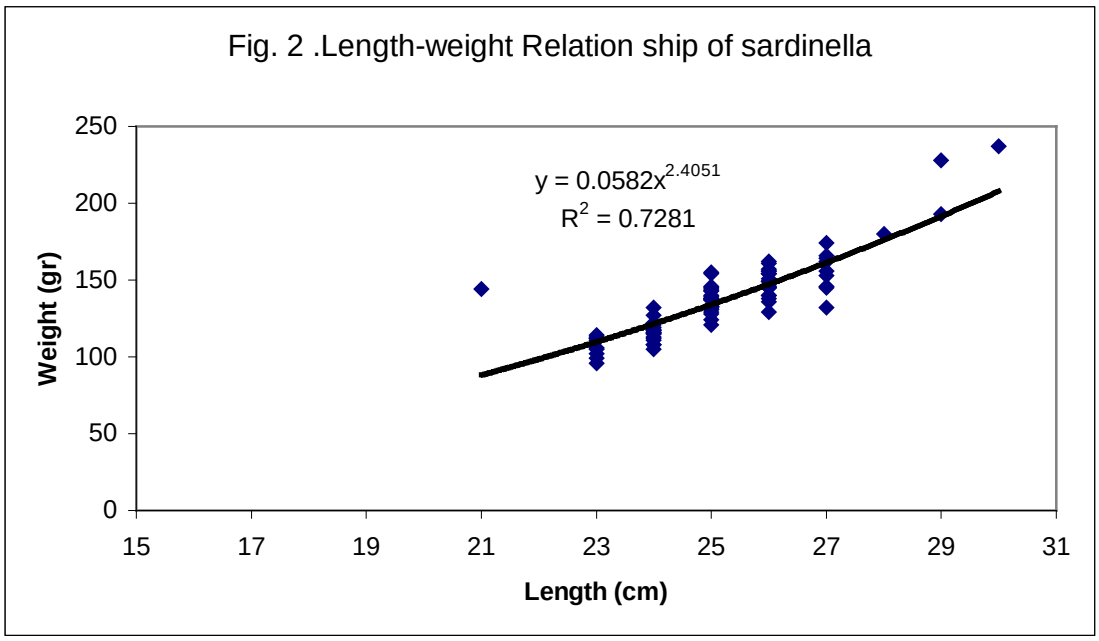
L_i = mid-length of fish in length group *i*.

L_{RMSL}= root mean square length

Using equation (3), the pooled length distribution is used together with the mean s_A-value to calculate the density by length groups for each observed area of distribution. The total number by length group in the area is obtained by multiplying each density by the area. Areas were calculated on the maps by using a digital planimeter (Tamaya Planix 7).

The number of fish was converted to biomass by length group, using the estimated weight at length from the estimated length-weight relationship, for sardinella, Figure 2.

$$\boldsymbol{W = 0.0582 L^{2.405}}$$



The two sardinellas were treated as one species during the scrutinizing process and the mean s_A values were later separated by species (*S. aurita* and *S. maderensis*) according to the catch rates and the length distributions of the two species.

CHAPITRE 3 RESULTS

3.1- **Density distribution of sardinellas**

The echo abundance of Sardinellas schools or single fish detections during nighttime is shown in the map in Figure 3. As evident, the Sardine was distribributed close to the coast, with high-density areas in northeastern and south eastern part of the investigated area. The R/V Dr. Fridtjof Nansen could not properly map the full inshore distribution, as the bottom depth here was less than 20 m.

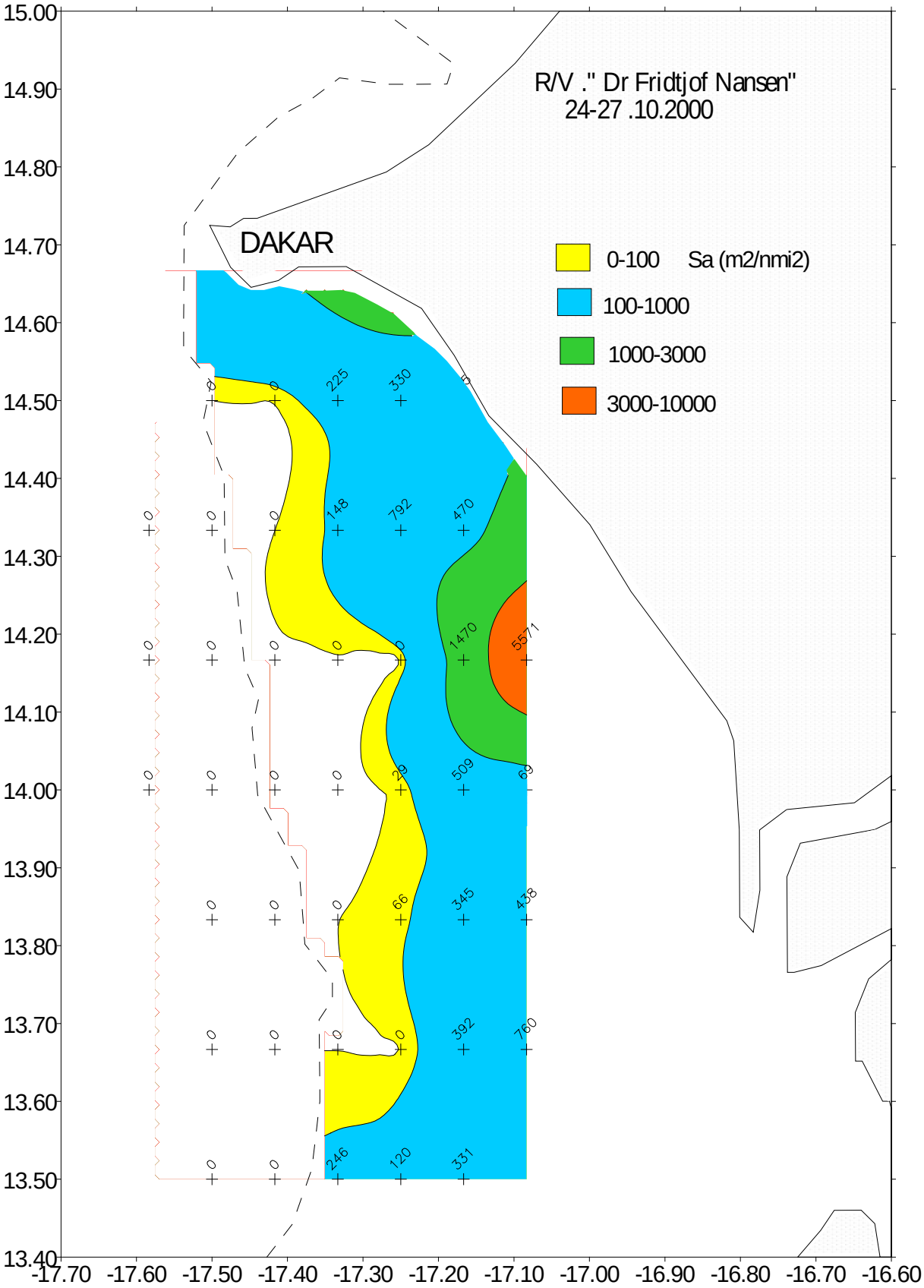
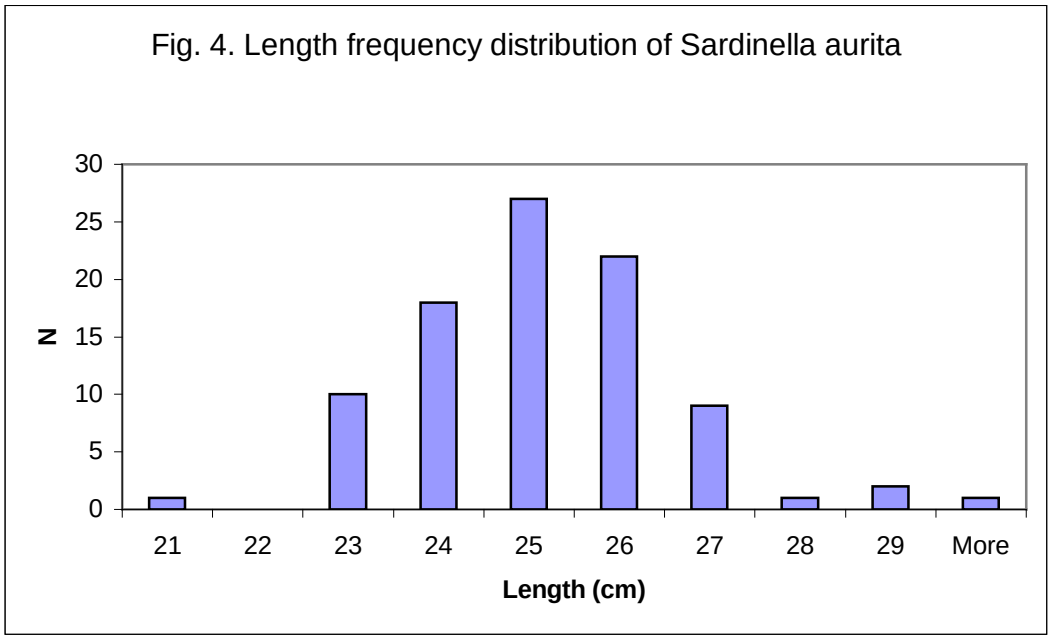


Fig. 3. Density distribution of sardinella

3.2 **Length frequency distribution of sardinella**

The length frequency distribution of *Sardinella aurita* shows a range from 21 to 30 cm with a peak at 25 cm.



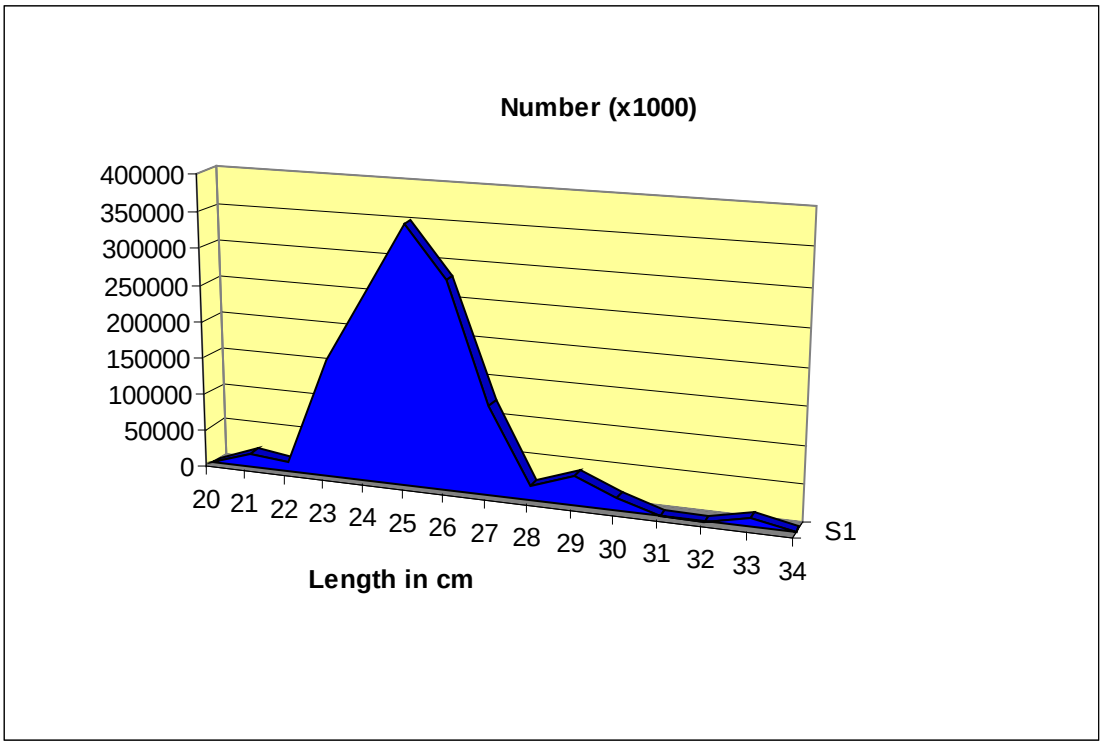
3.3 **Different Biomass estimates**

The biomass estimation was conducted using three different area expansion methods, the elementary square method, the manually contouring method, and the transect method. The results from this analysis are shown in ANNEX IV. Total biomass of Sardinellas recorded within the investigated area was about 150. 000 tonnes, Table 2:

METHOD	NUMBER (x 10^9)	BIOMASS (x1000t)
Elementary square	1.29	181
Manually contouring	1.05	147
Transect method	1.08	157

Details of the analysis are shown in ANNEX V.

Figure 5. shows a simple numbers and biomass by length of Sardinellas.



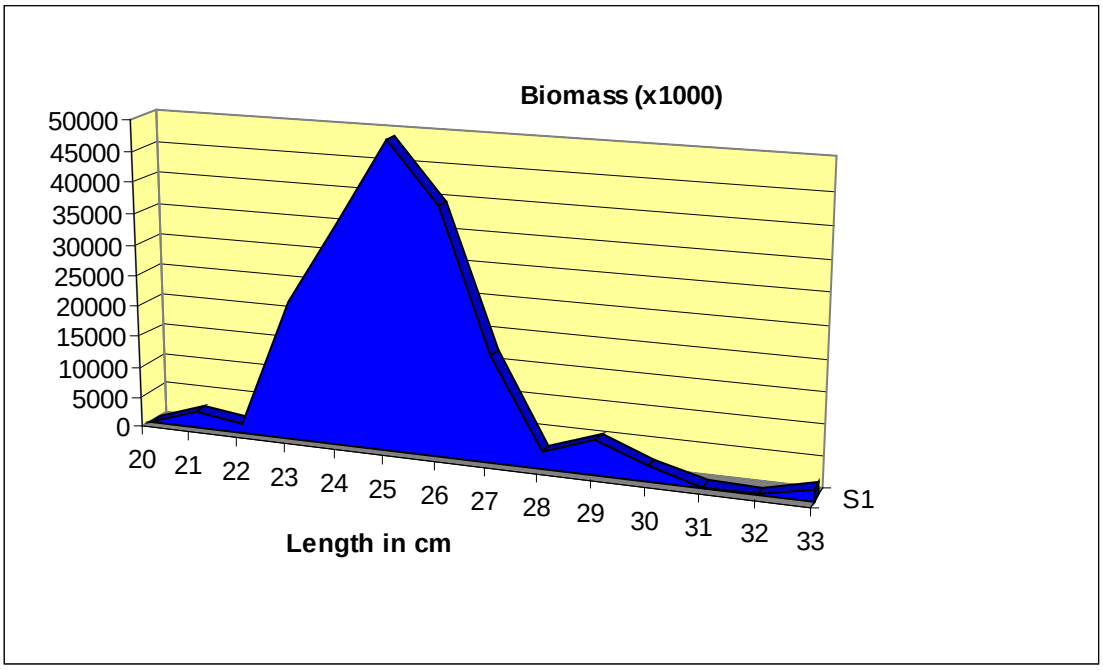


Fig 5. Numbers and Biomass by length class of Sardinellas

CHAPITRE 4 CRITIQUES AND CONCLUSIONS

The analysis using the transect method was used to estimate proper transect spacing transects, and this may indicate that 5 – 10 transects give a reasonable standard error on this contagiously distributed species. However, more observations are needed closer to inshore in order to estimate this stock of sardinella properly. The difference between the three methods may be explained mainly by the use or not use of along-coast data during computations.

More trawls stations should have been performed for improving the scrutinising of the acoustic data, although separating sardinella was seldom a problem in this survey.

The participants have asked for more courses in order to improve their understanding. Further, more advanced research also on target strength for sardinella is needed for improving the accuracy of the biomass estimate.

ANNEX I: Instrument Journal No.1 Calibration with sphere

Rev.10.97

Vessel : Dr. Fridtjof Nansen		Date: 24.10.2000	
Echo sounder: EK500_1		Locality: Dakar	
Transducer: ES 38B	Sphere: CU-60	Bottom depth: 21m	
Sound velocity:1535 m/s (measured at site)	Range to sphere 15,36 (m)	Temp at sphere :25.5 °C, Salinity at sphere :35 ?? °/oo	TS_{sphere} : -33.6 dB (Corrected for sound velocity, t ans S)

Transeiver no. : 1	Frequency: 38 kHz	Date for previous calibration: 0000

Settings in sound velocity menu during calibration:

Mean sound velocity between transducer and sphere: 1535 m/s (Settings should be varied after the conditons in the

Settings in the transiever menu:	Previous values:	Values obtained during this calibrations:	Values set in sounder after calibration:
Transducer depth (m) (Must be 0.0 during calibrations)	0	0	5,5 (draft)
Absorption coefficient (dB/km)	10	10	10
Pulse duration (ms)	Medium	Medium	Medium
Bandwidth (kHz)	Wide	Wide	Wide
Max transmit power (W)	2000	2000	2000
Equivalent beam angle (10 log Ψ) (dB)	-20,6	-20,9	-20,9
S_v transducer gain (dB)	26,50	27,5	27,5
TS transducer gain (dB)	26,50	27,6	27,6
Angle sensitivity alongship (fixed for transducer)	21,9	21.9	21,9
Angle sensitivity athwardship	21,9	21.9	21,9
3 dB beam angle (dB) alongship	7,1	6.92	6,92
3 dB beam angle (dB) athwardship	7,1	6.84	6,84
Alongship offset (deg)	0,10	0.10	0,10
Athwarthship offset (deg)	-0,05	-0.05	-0,05

Measured vales before adjustments (measured with sphere at axis):

Read TS of sphere: TS_{kule} : -31,5 dB	Read s_A of sphere : 11200 m^2/nmi^2

Theoretical s_A i the measured sphere depth (m^2/nmi^2)	7144

$$s_A = \frac{\sigma}{r^2 \psi} 1852^2 \qquad \sigma = 4\pi 10^{0.1TS}$$

Read s_A after adjustment of S_V transducer gain (m^2/nmi^2)	7018

Notes about the calibration and detected deviations:

Lobe data stored in file: Filename:

Weather conditions: Perfect ☐ Good ☒ Bad ☐ (Mark) Wind speed: 2,5 m/s

When changes in transducer gains are more than o.3 dB between calibrations, investigations should be made to explain the difference. If no error is detected, new calibrations should be performed within short time.

The calibration was conducted by: (sign.)

ANNEX II. Records of Fishing Stations

```
Dr. Fridtjof NANSEN              PROJECT:W3      PROJECT STATION:1174
      DATE:25/10/00             GEAR TYPE: PT No:6   POSITION:Lat   N  1330
                start   stop   duration                          Long  W  1713
       TIME  :19:50:04 20:19:53  30  (min)  Purpose code:  3
       LOG   :9774.43  9776.05  1.61        Area code    : 2
       FDEPTH:     10       10              GearCond.code:
       BDEPTH:     48       51              Validity code:
              Towing dir: 270ø  Wire out: 150 m  Speed: 30 kn*10

         Sorted:  40 Kg      Total catch:     40.38    CATCH/HOUR:     80.76

   SPECIES                                   CATCH/HOUR    % OF TOT. C   SAMP
                                          weight   numbers
   Scomber japonicus                        32.16      156      39.82
   Sardinella maderensis                    16.00       66      19.81
   Auxis thazard                            14.00       38      17.34
   Trachurus trecae                          9.90      130      12.26       3
   Selene dorsalis                           5.38        2       6.66
   Sardinella aurita                         2.00       14       2.48       2
   Dactylopterus volitans                    1.12        4       1.39
   Mullus surmuletus                         0.20        4       0.25
                                          _________           ________
   Total                                    80.76             100.01

      Dr. Fridtjof NANSEN              PROJECT:W3      PROJECT STATION:1175
       DATE:26/10/00             GEAR TYPE: PT No:6   POSITION:Lat   N  1403
                start   stop   duration                          Long  W  1704
       TIME  :13:32:10 14:01:38  29  (min)  Purpose code:  3
       LOG   :9957.17  9959.06  1.86        Area code    : 2
       FDEPTH:      0        0              GearCond.code:
       BDEPTH:     21       26              Validity code:
              Towing dir: 270ø  Wire out: 150 m  Speed: 40 kn*10

         Sorted:  47 Kg      Total catch:    184.58    CATCH/HOUR:    381.89

   SPECIES                                   CATCH/HOUR    % OF TOT. C   SAMP
                                          weight   numbers
   Sardinella aurita                       336.21     2400      88.04    1175
   Leptocharias smithii                     20.81       12       5.45
   Sardinella maderensis                    18.00      166       4.71    1176
   Selene dorsalis                           5.75        8       1.51
   Dactylopterus volitans                    0.99        4       0.26
   Decapterus punctatus                      0.12        4       0.03
                                          _________           ________
   Total                                   381.88             100.00

      Dr. Fridtjof NANSEN              PROJECT:W3      PROJECT STATION:1176
       DATE:26/10/00             GEAR TYPE: BT No:2   POSITION:Lat   N  1411
                start   stop   duration                          Long  W  1730
       TIME  :17:46:18 18:15:33  29  (min)  Purpose code:  3
       LOG   :9996.33  9997.85  1.52        Area code    : 2
       FDEPTH:    107      104              GearCond.code:
       BDEPTH:    107      104              Validity code:
              Towing dir: 180ø  Wire out: 380 m  Speed: 30 kn*10

         Sorted:  73 Kg      Total catch:   1458.00    CATCH/HOUR:   3016.55

   SPECIES                                   CATCH/HOUR    % OF TOT. C   SAMP
                                          weight   numbers
   Trachurus trecae                       1727.17    32979      57.26
   Boops boops                            1067.59    17545      35.39
   Scomber japonicus                       182.90     1241       6.06
   Ariomma bondi                            20.69      207       0.69
   Illex sp.                                 4.14       41       0.14
   Fistularia petimba                        1.66        2       0.06
   Capros aper                               0.41       41       0.01
                                          _________           ________
   Total                                  3004.56             99.61
```

Annex III Instruments and fishing gear used

The Simrad EK-500, 38kHz echo scientific sounder was used during the survey for fish abundance estimation. The Bergen Echo Integrator system (BEI) logging the echogram raw data from the sounder, was used to scrutinize the acoustic records, and to allocate integrator data to fish species. All raw data was stored to tape, and a backup of the database of scrutinized data, stored. The details of the settings of the 38kHz where as follows:

Transceiver-1 menu	Transducer depth	5.5 - 7.5 m
	Absorbtion coeff.	10 dB/km
	Pulse length	medium (1ms)
	Bandwidth	wide
	Max power	2000 Watt
	2-way beam angle	-21.0 dB
	SV transducer gain	27.45 dB
	TS transducer gain	27.65 dB
	Angle sensitivity	21.9
	3 dB beamwidth	6.8 dg
	Alongship offset	-0.03 dg
	Athwardship offset	0.06 dg
Display menu	Echogram	1
	Bottom range	10 m
	Bottom range start	10 m
	TVG	20 log R
	Sv colour min	-67 dB
	TS Colour minimum	-60 dB
Printer- menu	Range	0 - 50 or 0 -100 m and 100 - 350m
	TVG	20 log R
	Sv colour min	-63 dB
Bottom detection menu	Minimum level	-40 dB

A calibration experiment using a standard copper sphere, performed in Baia dos Elephantos 12 August 1999 gave the following results:

Sv Transducer gain 27.45 dB
Ts Transducer gain 27.65 dB

Fishing gear

The vessel has two different sized "Åkrahamn" pelagic trawls and one "Gisund super" bottom trawl. For all trawls, the Tyborøn, 7.8m² (1670 kg) trawl doors were used. Complete drawings of the trawls used are included.

ANNEXIV. Different biomass estimate of Sardinellas

EVALUATION TROUGTH MAPPING

	Sardinellas	
Length	Number	Biomass (T)
20	0	0
21	15674001	2194360
22	9677686	1354876
23	130929907	18330187
24	206238588	28873402
25	285978630	40037008
26	230223848	32231339
27	99553831	13937536
28	16132418	2258538
29	32264836	4517077
30	14502492	2030349
31	814963	114095
32	0	0
33	10427677	1459875
34	0	0
35	0	0
36		0
Tot	1.05E+09	1.47E+05

EVALUATION WITH ONA´S FORMULA

Length	Sardinellas	
	Number	Biomass (T)
20	0	0
21	19234213	2692790
22	11875888	1662624
23	160669490	22493729
24	253083878	35431743
25	350936172	49131064
26	282517180	39552405
27	122166612	17103326
28	19796755	2771546
29	39593511	5543091
30	17796606	2491525
31	1000075	140010
32	0	0
33	12796232	1791472
34	0	0
35	0	0
36		0
Tot	1.29E+09	1.81E+05

ESTIMATION OF BIOMASS BY TRANSECT METHOD

Nombre	Rad1	Rad2	Rad3	Rad4	Rad5	Rad6	Rad7	Rad8	Rad9	Rad10
1	0	0	0	0	0	0	10217	0	118	0
2	0	0	0	0	61	0	26104	0	25	0
3	0	0	0	0	75	0	4988	0	23	0
4	0	0	0	0	130	0	1136	0	32	0
5	0	0	0	0	288	0	0	0	179	0
6	0	0	234	0	1977	0	0	0	82	0
7	0	0	52	0	92	0	0	0	0	0
8	810	0	79	0	527	0	0	0	0	0
9	513	0	54	0	63	0	0	0	0	0
10	0	0	52	0	91	0	0	0	0	0
11	0	0	317	13.5	200	0	0	0	0	0
12	0	0	605	0	0	0	0	0	0	0
13	261	0	407	0	0	0	0	0	0	0
14	37	0	285	0	0	0	0	0	0	0
15	292	0	307	0	0	0	0	0	0	0
16	358	0	0	0	0	0	0	0	0	0
17	33	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	13.3	0	0	0	0	0	0	480	0	0
20	0	0	0	0	0	0	0	258	0	0
21	0	0	0	0	0	0	0	300	0	224
22	0	0	0	601	0	0	0	420	0	271
23	0	0	0	399	0	0	0	832	0	562
24	0		0	726	0	0	0	337	0	1192
25	0	535	0	615	0	0	0	1410	0	141
26	0	1816	0	243	0	0	0	1387	0	920
27	0	0	0	0	0	0	0	1360	0	387
28	0	0	0	0	0	0	0	208	0	224
29	0	337	0	0	0	0	0	242	0	281
30	0	2174	0	0	0	50	0	194	0	2010
31	0	6977	0		0	46	0	129	0	
32		1187	0		0	268	0	116		
33		4616				118	0			
34						46	0			
35						1132	0			
36						11777				
37						6606				
SAmoyenne	74.7516	551.3125	74.75	86.58333	109.5	541.7027	1212.71	239.781	14.8065	207.066667
Area(mn^2)	185	175	175	185	180	205	185	185	166	175
N	2.7E+07	187256866	25389322	31089082	3.8E+07	2.16E+08	4.4E+08	8.6E+07	4770468	70331536.3
w(tonnes)	3758	26216	3555	4352	5356	30175	60962	12054	668	9846
										156941

RMSL en cm	25.2
TS en db	-43.872
sigma en m^2	0.00052
w en gr	140