



Baltic Sea Research Institute Warnemünde

C r u i s e R e p o r t

r/v "Gauss"


Cruise- No. 11 / 03 / 02


21st – 31st March, 2003

Western and Central Baltic Sea

This report is based on preliminary data

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1. **Cruise No.:** 11 / 03 / 02
2. **Dates of the cruise:** from 21 March 2003 to 31 March 2003
3. **Particulars of the research vessel:**
 - Name: Gauss
 - Nationality: Germany
 - Operating Authority: Bundesamt für Seeschifffahrt und Hydrographie (BSH)
4. **Geographical area in which ship has operated:**
western and central Baltic Sea
5. **Dates and names of ports of call**
23.03.2003 Rostock
6. **Purpose of the cruise**
Monitoring cruise in the framework of HELCOM programme
7. **Crew:**
 - Name of master: K.P.Walde
 - Number of crew: 20
8. **Research staff:**
 - Chief scientist: R.Feistel
 - Scientists: H.Disterheft, P.Köster
 - Engineers: S.Weinreben
 - Technicians: B.Kayser, B.Buuk, B.Sadkowiak, U.Hehl
9. **Co-operating institutions:**
10. **Scientific equipment**
CTDO bathysonde, plankton net

11. General remarks and preliminary result

This monitoring cruise was prepared under the impression of an oxygen-rich salt water **inflow from the Kattegat in January 2003** which perhaps will exhibit a lasting effect on the deep water ventilation state. The cruise fitted into the expected time window of this signal arriving at the Gotland Basin. Additional stations were added there to the cruise track for an improved study of the possibly arriving renewal waters.

The cruise was carried out under continuously calm **weather conditions** with low winds and clear skies except for the night 30./31. March when a rain front passed with winds peaking at 16 m/s (BF 7) from west. Air pressure varied between 1035 and 1008 hPa, morning air temperatures between 0.5 and 5°C. Water surface temperatures have been measured between 1°C in the northern and 4.3°C in the western Baltic.

In following report text, oxygen concentrations are bottle values, or CTD sensor values post-processed correspondingly. O₂ data in the graphs are still raw CTD sensor values, low by a factor of 1.05 compared to bottle titration.

In the **western Baltic**, down to 50 m depth, temperatures were rather homogeneous about 2-3°C in the beginning of the cruise. This is by about 2°C below the values found in the previous year, likely lingering from the more severe winter 2002/03 compared to the very mild one in 2001/02.

In the **Fehmarn Belt** area, high surface salinities of about 13 psu have been found (21 March) together with near-bottom values of 26 psu, which considerably exceed salinities found there e.g. one year ago (9 and 18 psu). These high values are probably caused by the minor inflow registered in the Sound between 6th and 14th March, and recorded at Darss Sill surface waters in the middle of March, too.

At the **Darss Sill**, a salty layer of 5 m thickness with salinities between 15 and 18 psu is found (22 March) overflowing into the **Arkona Basin**. From there, a similar layer about 5 m thick with salinities 15 to 18 psu and oxygen above 7 ml/l is feeding waters into the deep levels of the Bornholm Basin. In comparison to February, 2002, the halocline has deepened (15 psu from 30 m to now 35 m) and has become more pronounced (8 to 17 psu from over 20 m to now 10 m layer thickness). At the bottom of the Arkona Basin, a lens of relatively oxygen-poor (< 5 ml/l), warm (> 3°C) and salty (> 22 psu) water was observed, indicating „old” bottom water which has neither been lifted nor completely mixed yet by the fresh inflow of January, 2003.

In the **Bornholm Basin**, the halocline is uplifted and weakened, just as opposed to the Arkona Basin. In comparison to March 2002, the 8 psu isohaline has moved from 56 m to 45 m depth, and the 15 psu surface from

82 to 62 m. Over the same period, bottom salinity has increased from 15.3 to 19.4 psu, oxygen from 0.7 to 5.1 ml/l, and temperature has dropped from 8.6 to 3.7°C. Vertical profiles are rather fluctuating, like temperature showing a minimum of 2.1°C at 40 m, a maximum of 4°C at 48 m, a minimum of 2.7°C at 50 m, a maximum of 4°C at 56 m, a minimum of 3.5°C at 63 m, a maximum of 3.9°C at 65 m, a minimum of 3.0°C at 72 m, and a maximum of 3.7°C at 86 m depth. Oxygen has a minimum of 6.1 ml/l at 67 m, a maximum of 7.0 ml/l at 75 m, and a minimum of 5.1 ml/l at 86 m depth. These figures are hinting on still ongoing exchange and renewal processes in the water column between the old permanent deep waters, the very warm inflow of October 2002, and the subsequent very cold inflow of January 2003. The latter has its centre not at the very bottom but at 72 m depth, suggesting that the warm autumn inflow had even denser waters than the current one, which have not been uplifted.

Compared to February 2003, oxygen has decreased at the bottom, but increased at about 60 m depth. Salinity has generally increased all over the profile, indicating a continuing feeding from the Arkona Basin storage of flown-in waters, but no longer into the deepest layers of the Bornholm Basin.

In the **Stolpe Channel** (station 222, #56, 25 March 2003) a homogeneous bottom layer of 15 m thickness with salinity 13.5 psu, temperature 4.5°C and oxygen 5.8 ml/l has been measured. These are the highest temperatures and salinities as well as the lowest oxygen values of the whole water column. In February 2003, the bottom water was warmer (6.8°C), saltier (18.5 psu) and less oxygenated (3.6 ml/l), suggesting that the deep water renewal is still progressing in this area, or at least intensified temporarily.

Further north-east towards the **Gotland Basin** (stations 256, 259, 255, 253, 26 March 2003) the flown-in waters could be traced all along the valley with continuously increasing temperatures from 4.8 to 5.6°C, strongly and non-monotonically varying salinities between 11.5 and 12.2 psu, and oxygen concentrations between 2.7 and 5.7 ml/l in a bottom layer between 5 and 10 meters thickness. The first impression is that the inflow jet is perhaps pulsating or meandering. Stations 256 and 259 have already continuous vertical profiles, while the more remote stations like 255 and even more 253 still possess an oxygen minimum (255: 1.6 ml/l, 253: 1.0 ml/l) and a temperature maximum (255: 5.3°C, 253: 6.0 °C) in the layer above the jet. All this supports an anticipated scenario of an inflow front currently propagating along the valley, with the successive stations along the way reflecting the temporal development of vertical mixing processes.

Station 250 (#61, 26 March 2003) shows the inflow process in an even “younger” stage. The bottom layer is almost 10 meters thick with $S = 12$ psu, $t = 5.7^\circ\text{C}$ and $\text{O}_2 = 2.8$ ml/l and apparently belongs to the recent inflow jet. Above it, centred at 100 m depth, is another layer of 10 meters with high temperatures (6.8°C) but low oxygen (0.7 ml/l, CTD), probably the uplifted and partly mixed remains of former anoxic bottom waters of February, 2003. Yet another thin layer at 86 m shows a temperature maximum (6.3°C) along with an oxygen maximum (2.4 ml/l) which is likely linked to the very warm October 2002 inflow which had carried oxygen into

the Gdansk Basin in November. No anoxic waters are observed at stations between the Stolpe Channel and here, although layers with $O_2 < 2$ ml/l still exist. Surface waters at this station possess an exceptional visibility of 12 m.

At station 263 (#62, 26 March 2003, morning) at 110 m depth a thick warm (6.6°C) and anoxic layer is existing yet. At the very bottom, a colder (5.8°C) 5 m layer is found with oxygen up to 2.3 ml/l and salinity 12.1 psu, which is considered to be a first effect of recent inflow jet. Surface waters at this station are perfectly homogeneous down to 60 m depth, where an extremely sharp thermo/halocline starts. After a couple of sunny and almost windless days, this is likely due to night convection. The night passed was clear and starry with ice formation at the ship's wires.

At station 260 (#63, 26 March 2003, afternoon), all waters below 110 m were anoxic. Only weak signs like the increasing salinity gradient and decreasing temperatures from 128 m downward are signalling the adjacent inflow. A weak thermal surface layer is newly formed over daytime.

After measurements performed on March, 27, the **Gotland Deep** station 271 is still mostly anoxic below 120 m depth. There are thin layers between 200 and 210 m with low oxygen and local peak temperatures, which very likely belong to the exceptional warm but small inflow of October 2002. Similar small warm oxygen signatures have been found all over the Gotland Basin area. The H_2S maximum is at 150m depth, and downward it even turns into traces of oxygen (0.1 ml/l) at the very bottom. In February 2003, there was still an H_2S maximum at the ground, and temperatures were lower (6.36°C) than this time (6.69°C), such that this faint ventilation should also be assigned to the warm October inflow, and not to the actual one.

At **Farö Deep**, bottom temperatures were steadily rising between October 2002 (6.06°C), February 2003 (6.20°C) and now (6.37°C), suggesting the arrival of the warm October inflow there already in February. There is still some H_2S is remaining; it is only slightly improving (Oct: -3.39, Feb: -3.18, now: -3.28 ml/l O_2 equivalent).

At **Landsort Deep**, temperature and oxygen values are fairly constant over the last half of the year. **Karlsö Deep** has almost the same bottom temperature as in February, but H_2S has increased from -0.7 to -1.2 ml/l O_2 equivalent.

Appendix: tables, maps and list of stations

Table 1: Preliminary data from the surface layer of selected regions

| Location / Date | Station / Number | Temp. °C | Salinity psu | NO₂₊₃ µmol/l | PO₄ µmol/l | SiO₄ µmol/l | O₂ ml/l |
|---------------------------------|-----------------------------|---------------------|-------------------------|------------------------------------|----------------------------------|-----------------------------------|-------------------------------|
| Kiel Bight 21.03.2003 | TF0360 9 | 2.38 | 13.58 | 2.0 | 0.02 | 0.61 | 9.06 |
| Mecklenburg Bight 22.03.2003 | TF0012 14 | 2.80 | 13.16 | 0.00 | 0.02 | 0.77 | 8.98 |
| Lübeck Bight 22.03.2003 | TF0023 10 | 2.85 | 12.13 | 1.12 | 0.02 | 0.96 | 9.00 |
| Arkona Basin 24.03.2003 | TF0113 39 | 2.52 | 7.46 | 0.01 | 0.06 | 2.91 | 10.39 |
| Oder Bight 24.03.2003 | OB4 29 | 2.49 | 6.07 | 25.48 | 0.02 | 17.70 | 10.72 |
| Bornholm Deep 25.03.2003 | TF0213 54 | 2.21 | 7.33 | 0.04 | 0.24 | 9.51 | 9.91 |
| SE Gotland Basin 26.03.2003 | TF0259 58 | 1.61 | 7.10 | 1.86 | 0.49 | 12.02 | 9.52 |
| Gotland Deep 27.03.2003 | TF0271 76 | 0.95 | 6.97 | 3.23 | 0.57 | 14.14 | 9.63 |
| Farö Deep 28.03.2003 | TF0286 83 | 0.69 | 6.87 | 3.13 | 0.57 | 14.10 | 9.74 |
| Landsort Deep 28.03.2003 | TF0284 88 | 1.34 | 6.65 | 1.59 | 0.46 | 12.92 | 9.78 |
| Karlsö Deep 29.03.2003 | TF0245 90 | 1.40 | 6.71 | 2.14 | 0.51 | 13.11 | 9.59 |

Table 2: Preliminary data from the near-bottom layer of selected regions

| Location / Date | Station / Number | Depth m | Temp. °C | Salinity psu | NO₂₊₃ µmol/l | PO₄ µmol/l | SiO₄ µmol/l | O₂ ml/l |
|---------------------------------|-----------------------------|--------------------|---------------------|-------------------------|------------------------------------|----------------------------------|-----------------------------------|-------------------------------|
| Kiel Bight 21.03.2003 | TF0360 9 | 16 | 2.12 | 20.42 | 0.64 | 0.16 | 1.61 | 7.55 |
| Mecklenburg Bight 22.03.2003 | TF0012 14 | 23 | 2.52 | 22.07 | 8.15 | 0.57 | 14.34 | 6.26 |
| Lübeck Bight 22.03.2003 | TF0023 10 | 21 | 2.05 | 20.57 | 6.53 | 0.39 | 8.89 | 7.40 |
| Arkona Basin 24.03.2003 | TF0113 39 | 45 | 3.09 | 20.99 | 4.80 | 0.44 | 9.75 | 6.92 |
| Oder Bight 24.03.2003 | OB4 29 | 10 | 2.06 | 6.80 | 9.27 | 0.02 | 2.53 | 10.38 |
| Bornholm Deep 25.03.2003 | TF0213 54 | 87 | 3.69 | 19.40 | 10.59 | 0.65 | 23.19 | 5.06 |
| SE Gotland Basin 26.03.2003 | TF0259 58 | 86 | 5.03 | 10.85 | 7.33 | 2.06 | 35.13 | 3.15 |
| Gotland Deep 27.03.2003 | TF0271 76 | 233 | 6.69 | 12.16 | 0.22 | 0.00 | 57.69 | 0.04 |
| Farö Deep 28.03.2003 | TF0286 83 | 188 | 6.37 | 11.54 | 0.00 | 5.73 | 70.52 | -3.28 |
| Landsort Deep 28.03.2003 | TF0284 88 | 430 | 5.41 | 10.24 | 0.00 | 4.20 | 54.77 | -1.02 |
| Karlsö Deep 29.03.2003 | TF0245 90 | 107 | 4.96 | 9.65 | 0.00 | 4.60 | 55.25 | -1.19 |

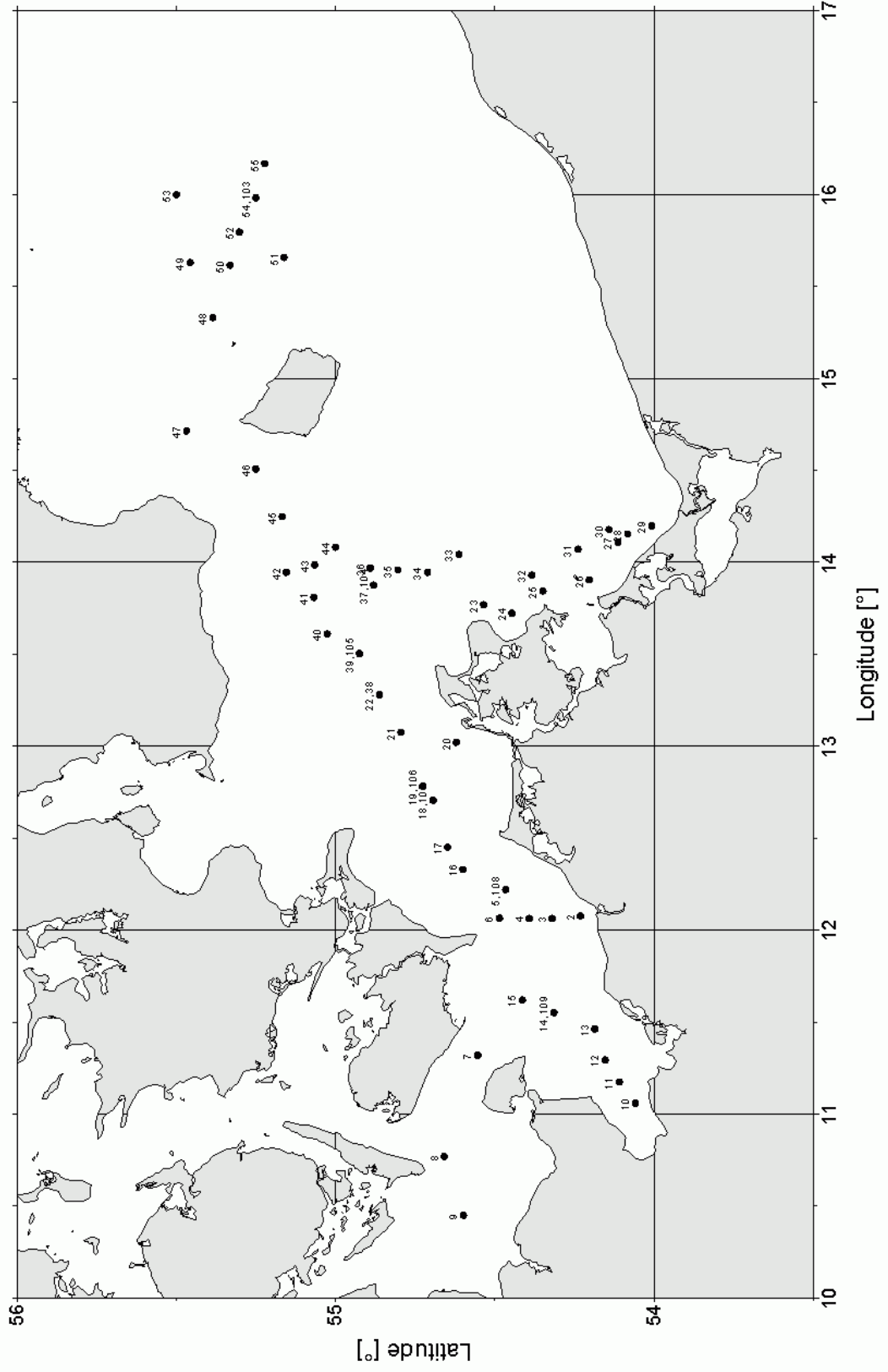
Station Map

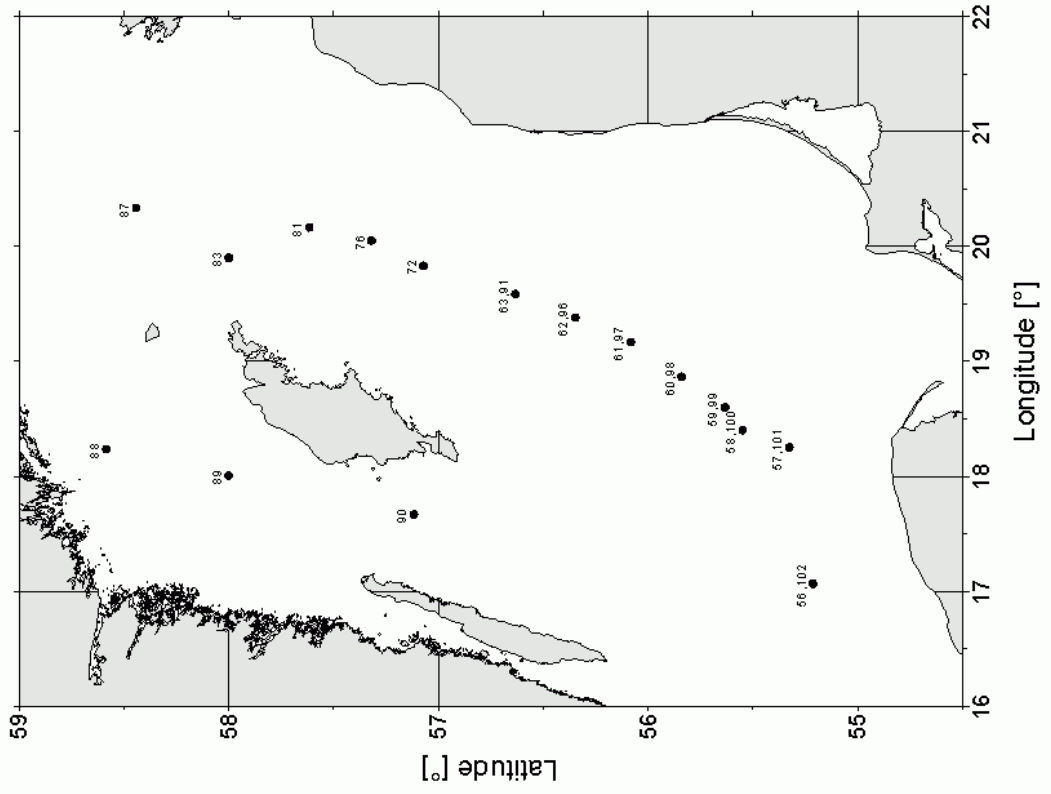
March 2003

FS Gauss

61 stations

21.03.03 - 31.03.03





Station Map

March 2003

FS Gauss

24 stations

27.03.03 - 30.03.03

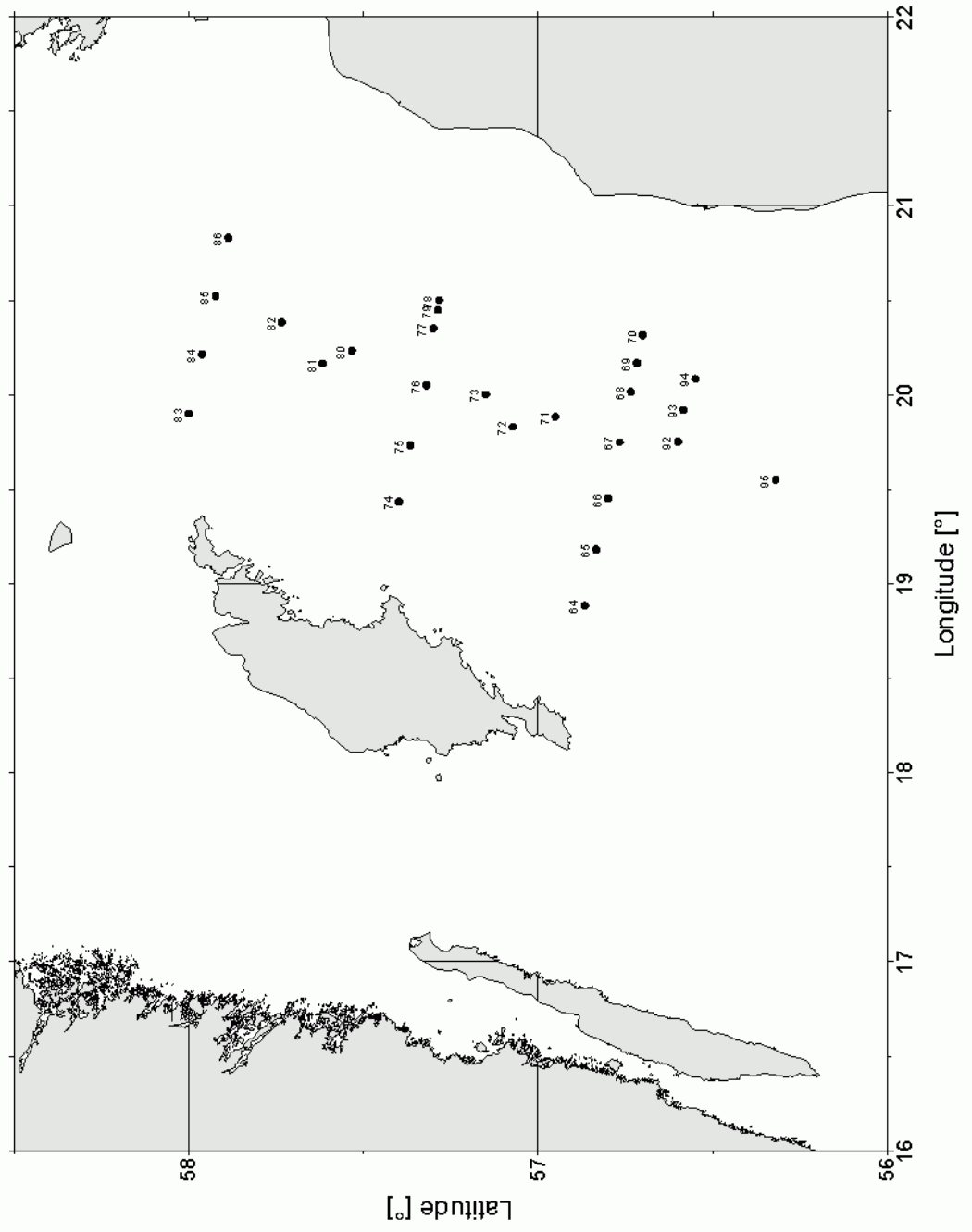
Station Map

March 2003

FS Gauss

27 stations

26.03.03 - 29.03.03



March 2003

FS Gauss

