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Dynamics and energy flow in the Baltic ecosystems - remote sensing.

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prepared for
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USA.

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ABSTRACT

The main aim of the study was to develop a technique for obtaining large-scale, synoptic views of ecological variables such as plankton blooms which could be used as a convenient operational tool for modelling the Baltic ecosystem.

Using all data from both the Stockholm archipelago and the off-shore test site in the Northern Baltic proper and from LANDSAT-2 tapes and ground truth measurements, a strong correlation was found between the product of bands 5 and 6 (5x6) and chlorophyll a.

The bluegreen bloom of Nodularia spumigena, typical for Baltic conditions was traced on two overpasses both by LANDSAT-2 and by use of helicopter tracks.

Indications of current gyres, upwelling sites and discharge plumes were obtained from the "topography" of the blooms. Using the Swedish automatic instrument IRIS (Image Reading Instrument System), Computer Compatible Tape (CCT) and programmes developed at the Swedish National Defence Research Institute, quantitative estimations of chlorophyll a and Secchi disc readings were made and transferred to multicoloured maps using an ink-jet plotter.

The combinations of techniques used should constitute a cheap, time-saving method of rough, large-scale quantifications of Baltic events. A continued processing of collected data will result in a rude quantification of a total bluegreen bloom in the Baltic, its biomass and contents of carbon, nitrogen and phosphorus.

## 1. INTRODUCTION

The overall objectives of the LANDSAT 2 investigation No 28 470 "Dynamics and energy flow through the Baltic ecosystem" was to study the production, transport and sedimentation of organic matter in coastal and offshore areas of the Baltic Sea.

The most specific objective was to develop a technique using the synoptic information extracted from LANDSAT 2 registrations to obtain basic information on ecological parameters such as intensity and large scale distribution patterns of phytoplankton blooms, particulate matter and effluents from urban and industrial areas.

Such a technique, if successful, would add a new dimension to information on the ecology of the Baltic Sea and constitute an important tool for the management of this semi-enclosed sea.

This report will primarily describe an empirical approach of how to extract chlorophyll and water quality information from two successful registrations in 1975 and how to process distribution maps of these parameters in the northern Baltic.

## 2. TECHNIQUES

### 2.1 Test sites and registrations.

The investigation was carried out as a joint study where several Swedish and other Baltic institutes participated.

The geographical location of the sea truth stations are plotted in Fig. 1 a with reference to the respective institute. A complete list of participants are presented in Appendix A together with sea truth measurements. Fig. 1 b shows the geographical location of LANDSAT 2 registrations recived during the investigation period of the Baltic sea.

Table 1 sums registrations, both those of value and those not useful due to cloudiness, artifacts and lack of truth data, financial or personnel shortage.

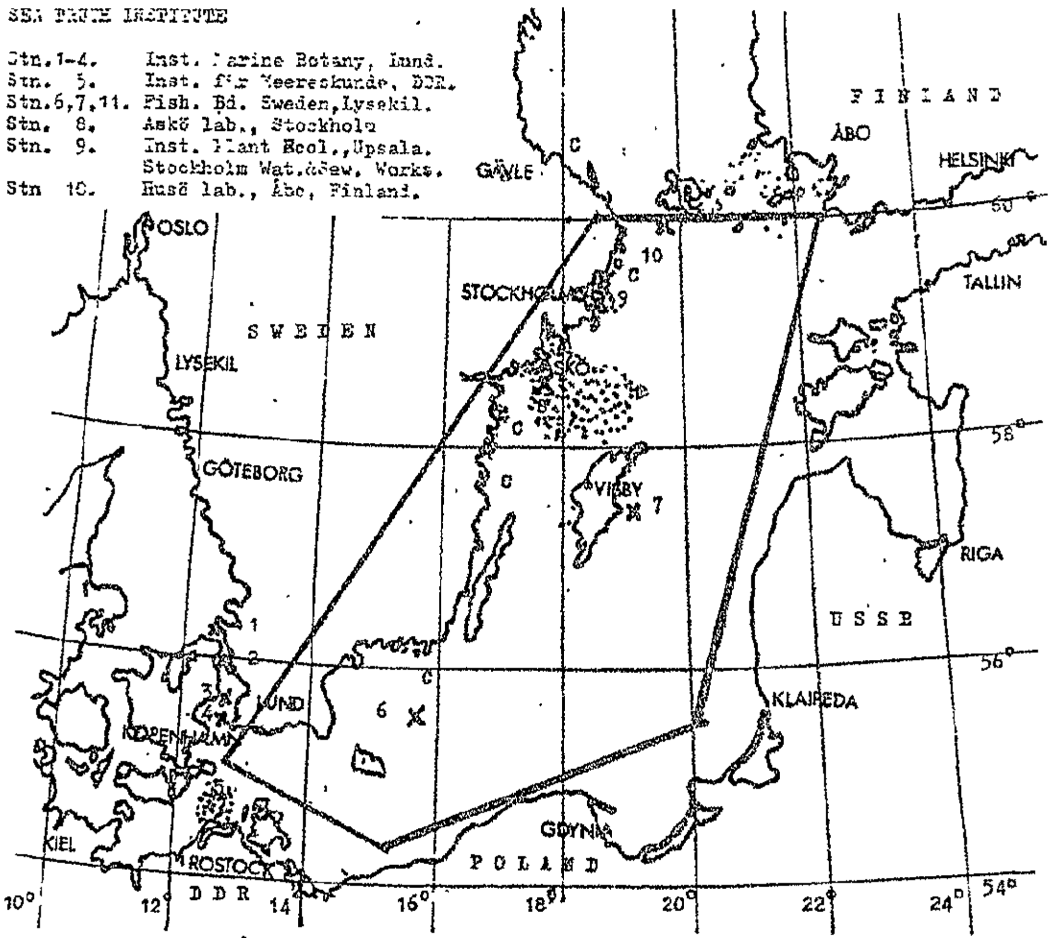



Figure 1a. Sea truth stations ( x = fixed, dotted = cruising areas) during the LANDSAT-2 experiment in the Baltic Sea 1975.

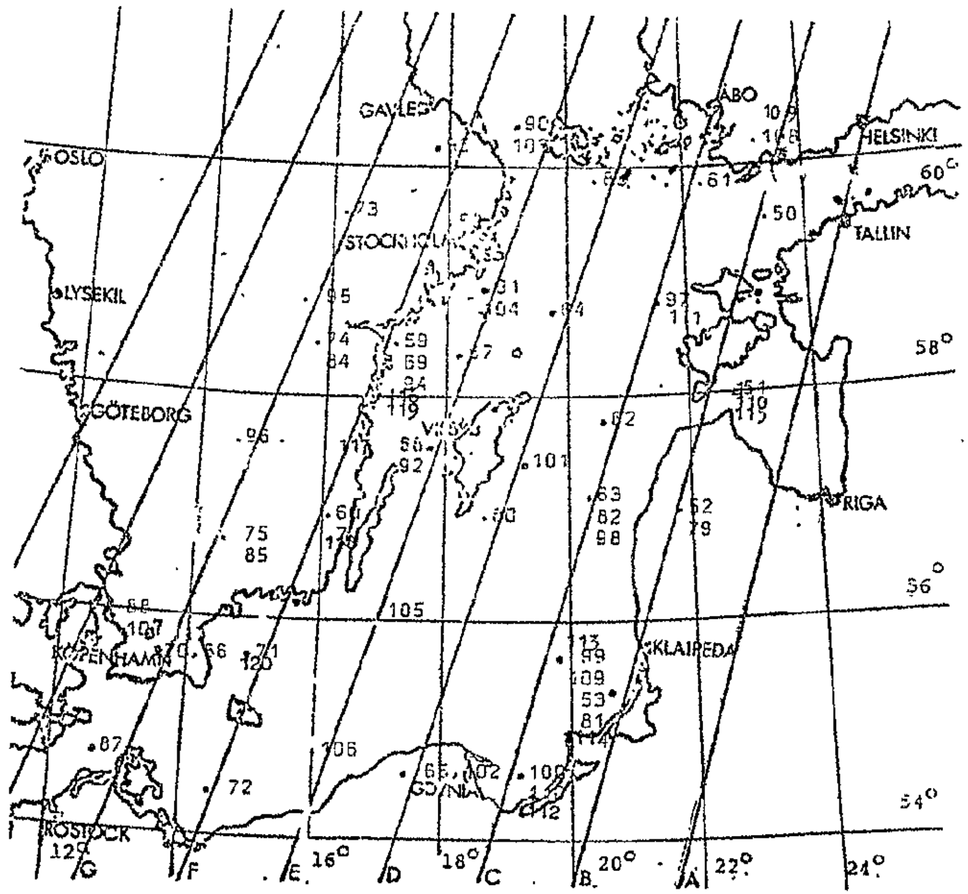



Figure 1b. LANDSAT-2 registrations of the Baltic Sea 1975. Picture center(approx.) in connetion to scene number(internal).

Figure 2 a. LANDSAT-2 registration July 20, 1975 showing the two main sea truth areas, Stockholm archipelago and off shore Landsort with approx. transect for continouos chlorophyll a measurements.

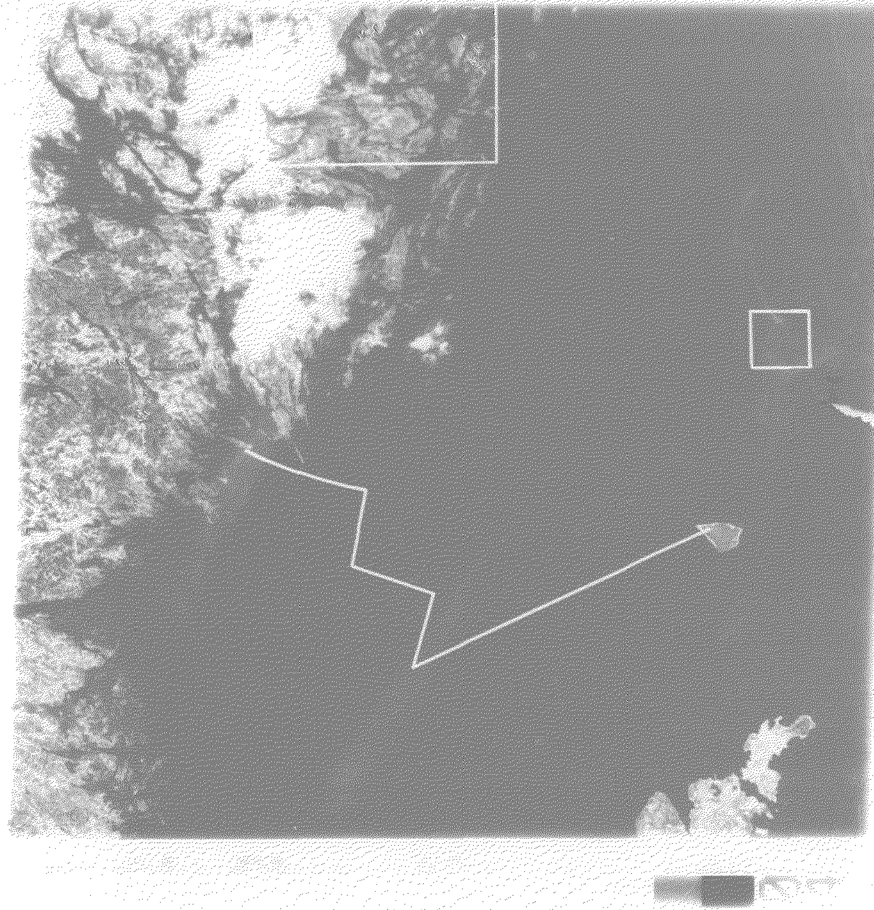


Figure 2 b. LANDSAT-2 registration August 6, 1975 showing the two main sea truth areas and approx. transect for continuous chlorophyll a measurements.
Area I with blue-green aggregation in the surface water.

TABLE 1 Registration statistics over useful and not useful scenes due to different causes.

| Characteristics | Number | Percent |
|---|---|---|
| Cloudiness and/or condensation streaks from aircrafts | 21 | 35 |
| Artifacts in the registrations | 7 | 12 |
| Registrations over land | 7 | 12 |
| Missing sea truth due to geographic location | 6 | 10 |
| other difficulties | 7 | 12 |
| Successful registrations used | 12 | 20 |
| Total number of registrations obtained | 60 | |

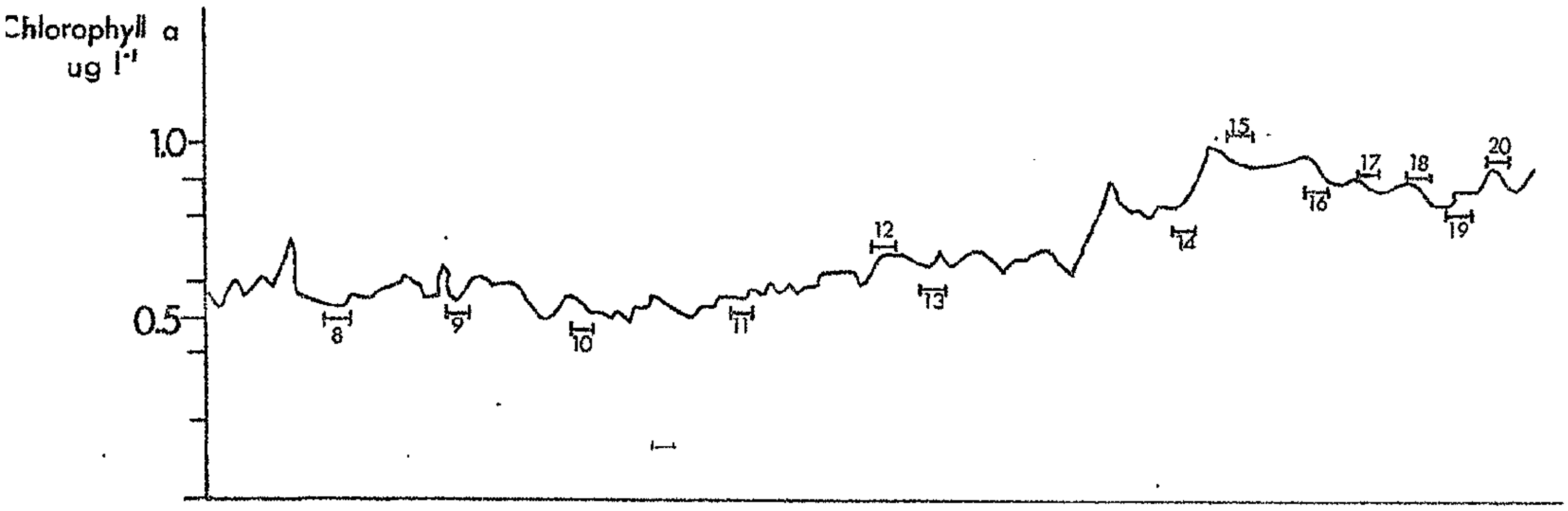
2.2 Sea truth measurements and analysis.

The sea truth measurements presented in Figure 1 b were taken at 10 fixed stations and during cruises in the Stockholm archipelago and off shore south of Landsort (see Fig. 2).

During the off shore cruises in the Landsort area chlorophyll a was continuously measured at 1 m depth by pumping water into the ship laboratory using the in vivo fluorescence technique described by Strickland and Parsons (1972). Figure 3 shows a compressed recorder output from the transect August 6. The chlorophyll a values have been calculated from the expression found in Figure 4.

During the continuous sampling, water was pumped around the Turner III instrument and collected in a 100 l jar corresponding to 2 naut. miles and subsampled for chlorophyll a, nutrients, salinity and phytoplankton counts. For analysis procedure see Strickland and Parsons 1972. Secchi disc measurememts were made using a 30 cm disc and water telescope.

This report is concentrated around two registrations, July 20 and August 6 (Figs. 2 a and 2 b) where sea truth measurements were performed synchronous to the satellite in the off shore area, while the measurements in the Stockholm archipelago were taken 3 - 5 days earlier in July and 2 - 6 days earlier in August. Investigations have shown that during this time of the year, the water in the different basins have almost the same character



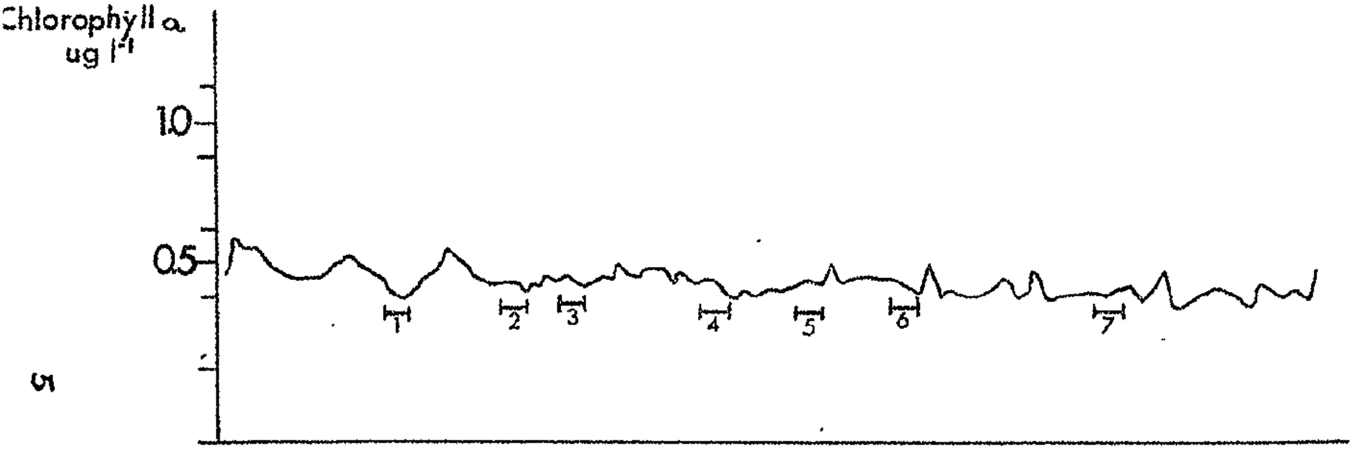




Figure 3. Compressed recorder output along the transect August 6,1975 ( fig. 2b) showing the in vivo measurement of chlorophyll a.

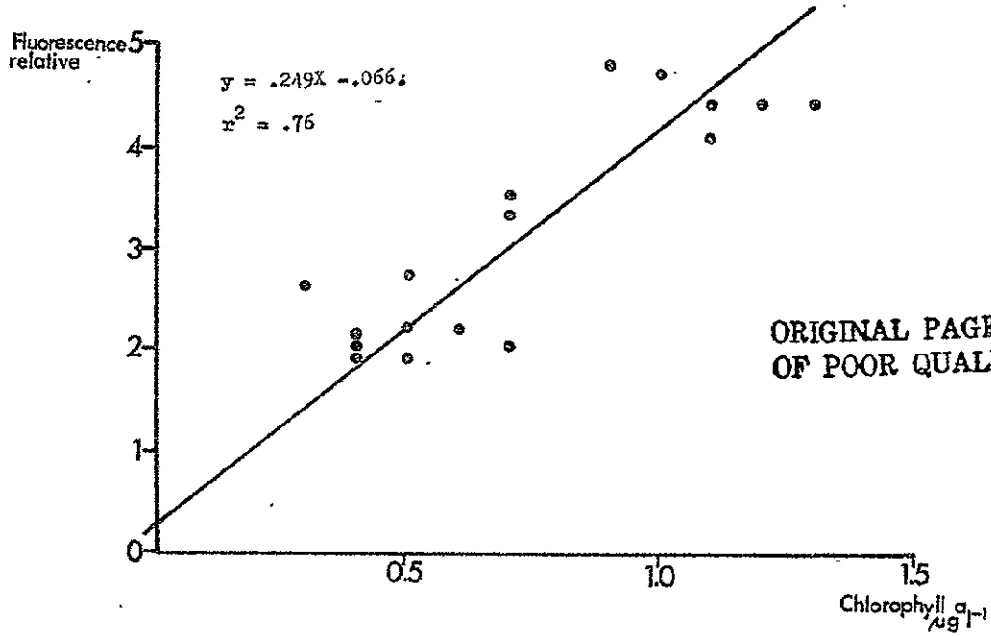



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Figure 4. Fluorescence vs. chlorophyll a during sea truth measurements August 6, 1975.

for weeks due to low inflow from lake Maelar and calm weather (Karlgren and Ljungström 1975) which persuaded us to use these values in order to expand the range of the sea truth measurements.

2.3 Satellite data interpretation and processing.
As a first step in handling the LANDSAT 2 registrations the 70 mm negative products were checked to find out if the scene was useful or not. This judgement was built on degree of cloudiness and quality of the negatives and the presence of synchronous sea truth measurements.

Selected scenes containing relevant information, e.g. algal blooms, were further interpreted qualitativly using a light table and a stereoscope.

Direct measurements on the 70 mm products were carried out on an automatic instrument, IRIS (Image Reading Instrument System, ref. Appendix B) where density differences in the algal accumulations were recognized.

This technique has not yet been fully tested but the results obtained are promising for a rapid areal quantification of specific characters of the surface water, and will be tested

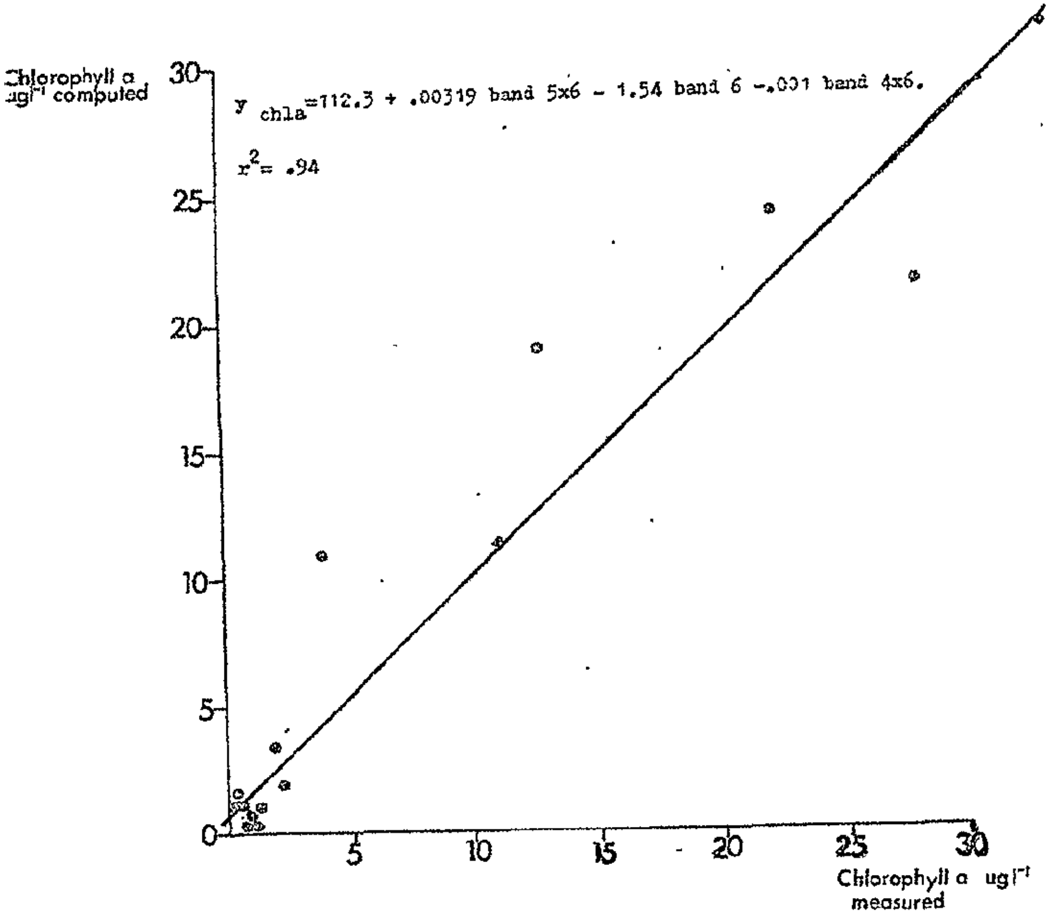



Figure 5. Graf showing computed vs. measured chlorophyll a using stepwise linear regression. Sea truth was collected off shore and in Stockholm archipelago. LANDSAT-2 digital numbers in registration August 6, 1975(ID. 2196-0917200) were used.

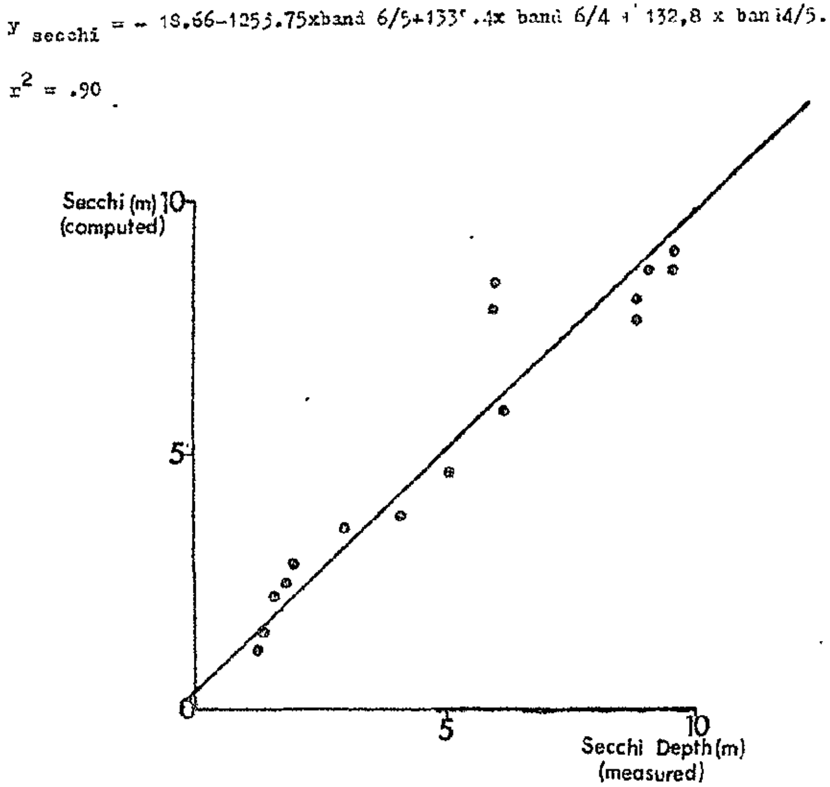



Figure 6. Graf showing the relation computed vs. measured turbidity (secchi disk) using stepwise linear regression. Sea truth was collected off shore and in Stockholm archipelago. LANDSAT-2 digital number in registration August 6, 1975 (ID. 2196-0917200) were used.

further.

Quantitative estimations of chlorophyll a and Secchi disc measurements have been made using the Computer-Compatible Tapes (CCT) processed on an IBM 360/75 at the Stockholm Computer Center, using programs developed at the Image Processing Section of the Swedish National Defence Research Institute (Appendix C).

The following procedures were used in correlating the satellite data to sea truth measurements:

The sea truth stations were located on sea charts, off shore by the Decca Navigation System.

Subscene extraction from the LANDSAT registration over the areas of sea truth measurements.

Symbol coded liner printer sheets covering the subscene areas of registration were used in location of the sampling stations. Window extractions, usually 24 pixels in the archipelago and 240 pixels off shore, were submitted to statistical treatment.

Mean values of the digital numbers in Band 4, 5 and 6 for each sampling station were calculated, using the program library.

2.4. Statistical handling of sea truth and LANDSAT data.
Stepwise regression analysis were used to find out which band or algebraic combination of bands showed the strongest relation to sea truth measurements as dependent variables and digital numbers of band 4, 5 and 6 as independent variables. The calculations were carried out on an IBM 360/75 using a Biomedical computer program (BMD02R).

Expressions to be used in generation of chlorophyll a and turbidity distribution maps by a PDP 11/40 with an inkjet plotter display were also obtained (for exampel see Figs. 5 and 6).

3. RESULTS

3.1 Eutrophication monitoring
LANDSAT 2 registration from August 6, 1975 (ID.2196-0917200) over the north-western part of the Baltic, have been used in an attempt to generate maps for chlorophyll a and turbidity (Secchi disc readings) from the inner part of the Stockholm archipelago towards the open Baltic. Stepwise regressión ana-

lysis was used to find out which band or algebraic combination of bands showed the strongest relation to sea truth measurements. The digital numbers of band 4, 5 and 6 were used as independent variables and the field measurements constituted dependent variables. By using this technique in three steps an equation was established. There was however a very small increase in significances compared with using just one step. Figure 7 is a representative example.

STEP NUMBER 1
VARIABLE ENTERED band 5x6.

MULTIPLE R 0.9360
STD. ERROR OF EST. 39.5199

ANALYSIS OF VARIANCE

| | DF | SUM OF SQUARES | MEAN SQUARE | F RATIO |
|---|---|---|---|---|
| REGRESSION | 1 | 154512.000 | 154512.000 | 98.930 |
| RESIDUAL | 14 | 21865.570 | 1561.826 | |

STEP NUMBER 2
VARIABLE ENTERED band 6.

MULTIPLE R 0.9600
STD. ERROR OF EST. 32.6183

ANALYSIS OF VARIANCE

| | DF | SUM OF SQUARES | MEAN SQUARE | F RATIO |
|---|---|---|---|---|
| REGRESSION | 2 | 162546.187 | 81273.062 | 76.383 |
| RESIDUAL | 13 | 13831.391 | 1063.953 | |

STEP NUMBER 3
VARIABLE ENTERED band 6x4.

MULTIPLE R 0.9736
STD. ERROR OF EST. 28.9644

ANALYSIS OF VARIANCE

| | DF | SUM OF SQUARES | MEAN SQUARE | F RATIO |
|---|---|---|---|---|
| REGRESSION | 3 | 166310.375 | 55436.789 | 66.080 |
| RESIDUAL | 12 | 10067.230 | 838.936 | |

Figure 7. Representative example showing small increase in strength of relationship using a 3 step linear regression analysis.

Table 2 shows the highest correlation coefficient (r) and the bands used in the statistics. As can be seen no clear differences appear in the selected bands or band combinations probably because of the strong correlation between Secchi disc values and chlorophyll a which indicates that the phytoplankton population to a great extent affected the turbidity both in the archipelago and off shore during these investigations.

TABLE 2 Correlation coefficient (r ) and band combination which yielded the highest correlation by stepwise regression calculations.

| | Chlorophyll a | | Secchi disc | |
|---|---|---|---|---|
| | r | Band | r | Band |
| July | | | | |
| Archipelago | .97 | 4+5 | .89 | 5 |
| Off shore | .90 | 5+6 | - | - |
| Arch. + off shore | .95 | 4x5 | .81 | 4+5 |
| August | | | | |
| Archipelago | .72 | 4 | .87 | 4+6 |
| Off shore | .97 | 5+6 | .56 | 4x5 |
| Arch. + off shore | .97 | 5x6 | .90 | 5/6 |
| July + August | | | | |
| Archipelago | .65 | 5+6 | .76 | 5+6 |
| Off shore | .96 | 5x6 | .46 | 4/6 |
| Arch. + off shore | .88 | 5x6 | .87 | 6 |

The regression analysis for all values, digital numbers and sea truth measurements collected during July 20 (ID.2179-09232) and August 6, show that chlorophyll a is best correlated to band combination 5x6 and turbidity to band 6.

The strong significant correlation between the two sets of data could probably be enhanced by several parameters in the water e.g. yellow substances and other dissolved substances (not measured here).

Our attempt in generating distribution maps met with difficulties due to differences in the detectors signals or in the calibration. Work has been done at the Institute for Image Processing to overcome the striping by smoching techniques built on the floating mean approach where the output of each pixel was weighed by the surrounding digital numbers. Figures 8 and 9 show the uncorrected and corrected products from the algal aggregation in Fig. 2b.

Another approach was tested in Figure 10 where the combination, of bands 5x6 found in Table 2 (August 6, archipelago + off shore), were used together with reduction of the scale by taking the

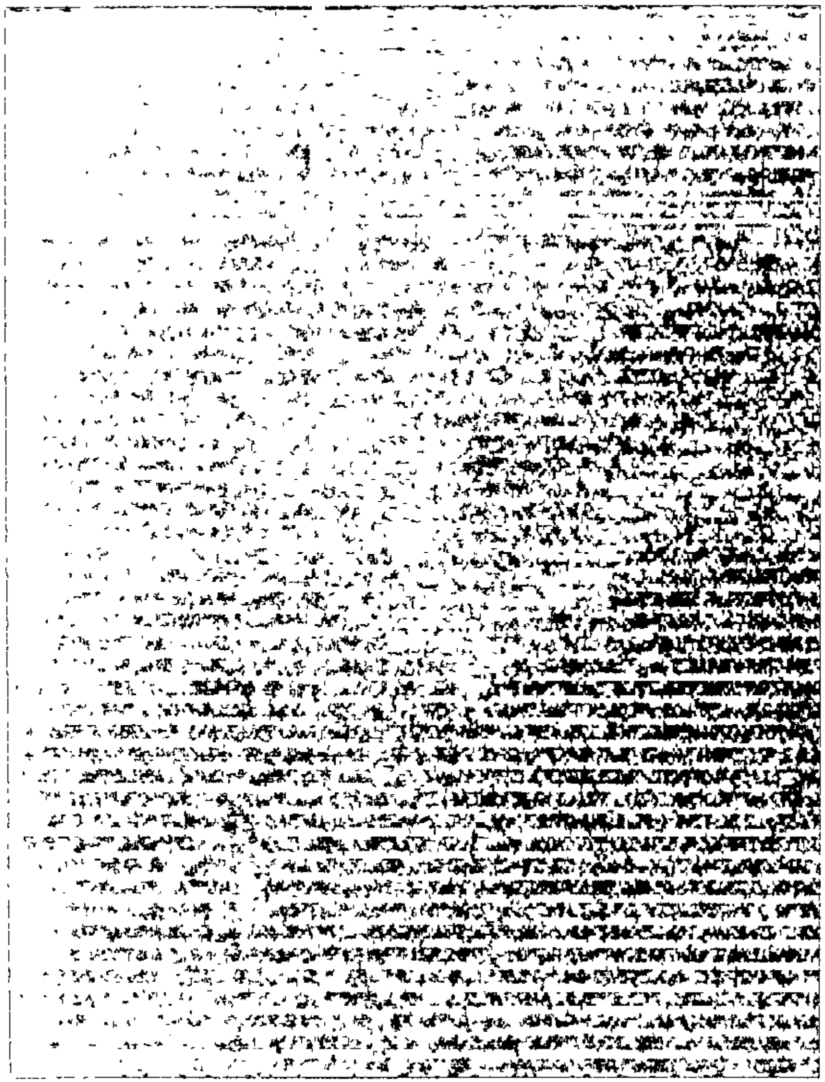


FIGURE 8. UNCORRECTED CCT-DATA (BAND 6) SHOWING BLUE-GREEN ALGAL AGGREGATION IN THE SURFACE WATER OF THE NORTHERN BALTIC (SEE FIGURE 2B), GENERATED AT FOA BY HERTZ INK-JET PLOTTER OUTPUT CONNECTED TO A PDP 11/40 COMPUTER.

FIGURE 9. CORRECTED CCT-DATA PRODUCT (BAND 6) SHOWING THE SAME ALGAL AGGREGATION AS IN FIGURE 8.

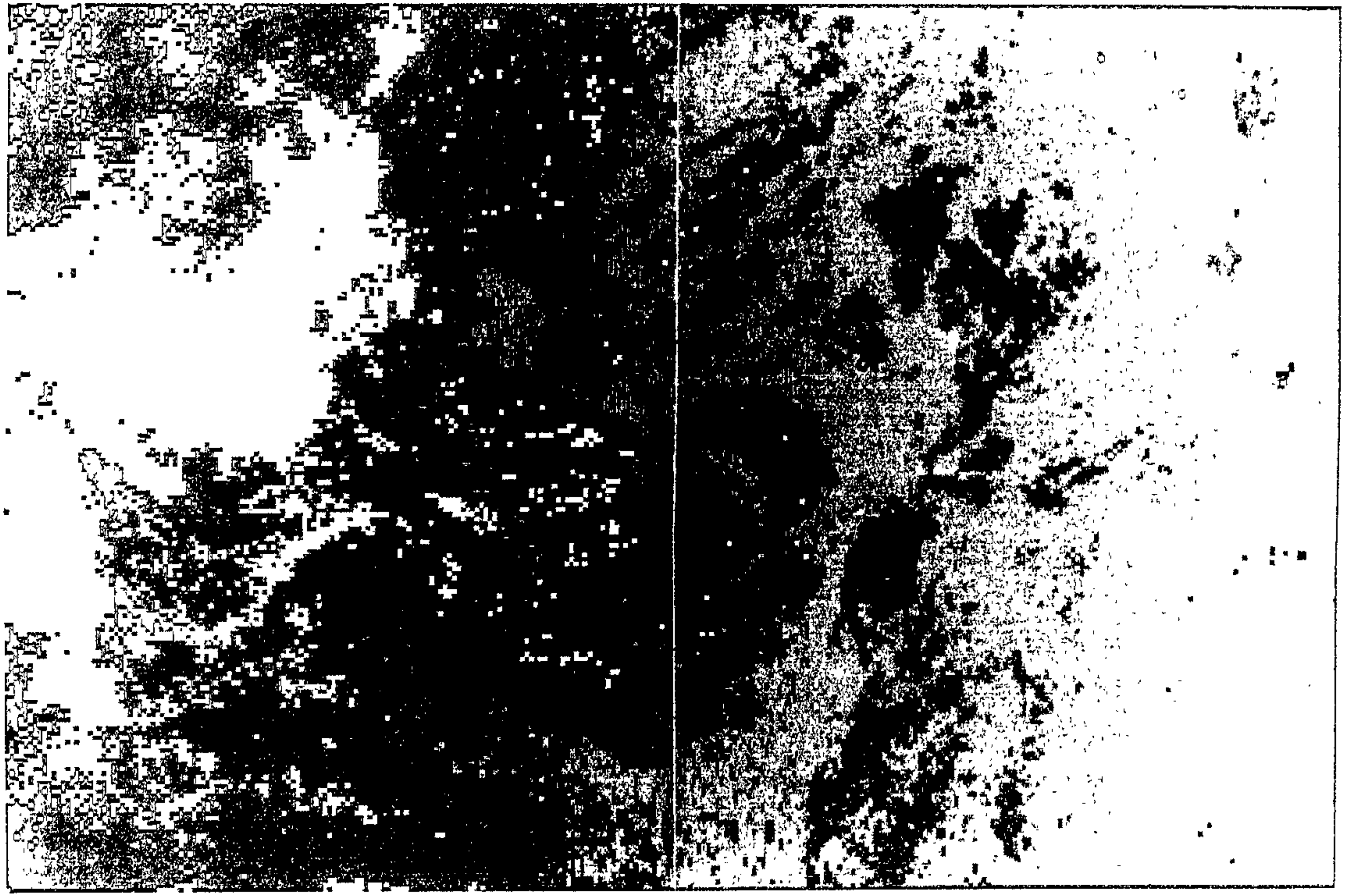


FIGURE 10. LANDSAT-2 COMPUTER PRODUCT, SHOWING THE CHLOROPHYLL a DISTRIBUTION FROM THE INNER PART OF STOCKHOLM ARCHIPELAGO TOWARDS OFF-SHORE AREAS. THE DIGITAL INFORMATION FROM THE SATELLITE HAVE BEEN PROCESSED ON A IBM 75/360 AND CONVERTED TO PDP 11/40 FORMAT FOR GENERATION BY INK-JET PLOTTER. THE WHITE AREAS ARE CLOUDS, GREEN ARE MAIN LAND AND ISLANDS, AND RED-PINK-MAGENTA-BLUE-LIGHT BLUE REPRESENT DIFFERENT CHLOROPHYLL a LEVELS.
(RED $>$ 30 μg/l, PINK 29-10 μg/l, MAGENTA 19-10 μg/l, BLUE 9-4 μg/l and LIGHT BLUE $<$ 4 μg/l)

the mean value of 3 line pixels and 4 column pixels as the output. The different colours generated on PDP 11/40 connected to an inkjet plotter, represent different relative density classes of chlorophyll a concentrations.

In Fig. 10 green represents land or skerries, white is clouds and red-pink-magenta-blue-lightblue show decreasing values of chlorophyll a.

When a more satisfactory method of over coming the striping by separate calibrations of the sensors is available LANDSAT data could probably easy be used in productivity monitoring along the coast.

3.2 Urban and industrial effluents.

Because of above mentioned difficulties only 70 mm products have been interpreted concerning the effluent studies. By this crude technique two main systems can be seen.

I. Effluents having an archipelago as a recipient characterized as follows (Stockholms archipelago, Fig. 2):

No plume or small emmisions can be detected in the LANDSAT imagery and there are relatively high chlorophyll a contents in the water within the area.

The recipient functions as a sink for nutrients and organic matter by sedimentation.

II. Effluents having no archipelago: (e.g. Wisla-Poland, Venta-USSR). Plumes can be detected outside the river mouth (Figs. 15 and 16). Nutrients and organic matter are distributed out into the Baltic. As no truth measurements have been reported from these areas no further interpretations have been done, but as a subjective impression areas having no archipelago could possibly act as nuclec for algal blooms.

3.3 Algal blooms.

The phenomenon called algal blooms is here understood as accumulation of planktonic algae in the surface water. During the summer season the Baltic phytoplankton population shifts from a dominance by diatomeés and dinoflagellates to bluegreen species (Nodularia spumigena, Aphanizomenon flosaquae) and monads. See Fig. 11.

Figure 11. A mosaic of the Baltic Sea, where features in the surface water below the clouds are aggregations of blue-green algea. Registrations from August 4-6, 1975 were used in this composite.

The aggregation of algae in the surface water is most pronounced for Nodularia spumigena. It occurs when the algae lose control of their gas vacouls and begin to float. This is a rapid process, within 24 hours for certain species (Reynolds 1971), but Figure 12 is more relevant for Baltic conditions.

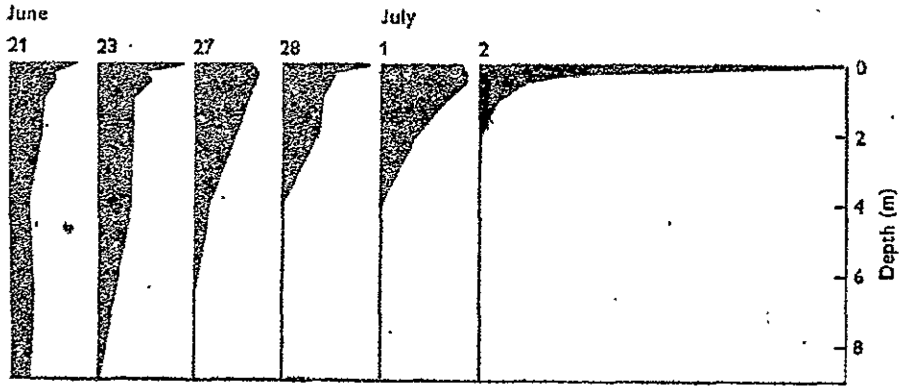


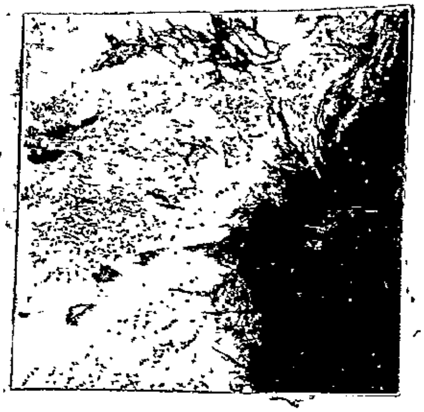

Figure 12 Vertical distribution diagrams of *Anabaena circinalis* in Crose Mere, Shropshire, during 1968. Re-drawn from Reynolds (1971, fig. 7).

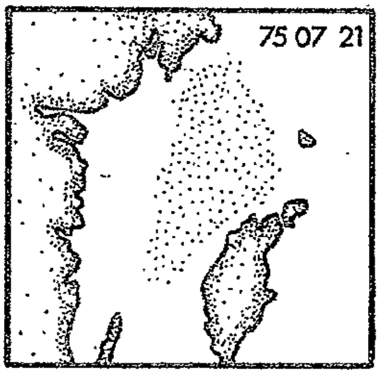
This pertubation of the buoancy-regulating mechanism is caused by several environmental factors such as nutrient deficiency, and turbulance decrease.

In the Baltic the blooms are often observed after a period of calm weather, temperatures above 17°C in the surface water and high insolation. The aggregation often occurs at the borders between Langmuir cells and in the area between off shore and coastal waters.

Figure 13 shows a picture sequence built on LANDSAT 2 registrations and helicopter observations reference during the blue-green bloom in 1975 indicating the irregular appearance of the bloom in the northern Baltic.

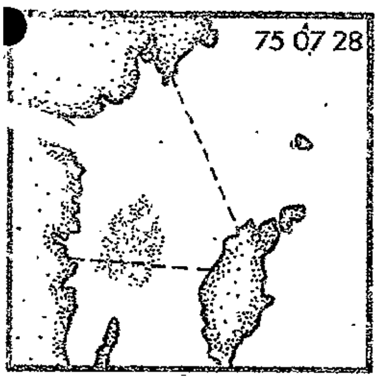
This means that total biomass estimations from satellite data must be carefully interpreted, although the qualitative information obtained has given Baltic ecologists another scale to consider in sampling design and measurements from research vessels.

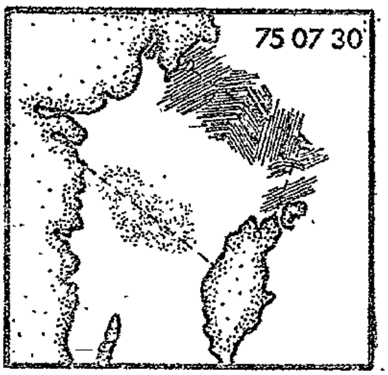





Left: Registration July 20, 1975 documenting the first phase of the blue-green algal aggregation in the surface water.

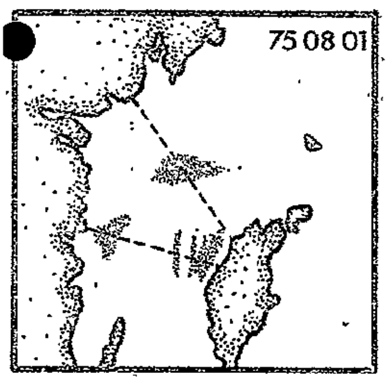
Right: Blue-green algae evenly distributed in the surface water (0-2m) starting about 4-5 naut. miles from the mainland.

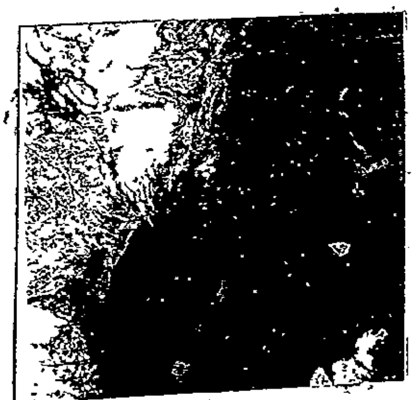



Left: No algae were detected in the NW-SE route but occured in the W-E fligth path.

Right: Heavy aggregation in the northern part with changing densities and directions. The other route show moderate density in the surface water.



Left: Blue-green algae present in the surface water but to a lesser extent.

Right: LANDSAT-2 registration August 6, 1975 showing the finale stage of the bloom.



Figure 13. A set of situations showing the variations in the blue-green algal bloom appearence in the NW Baltic during 1975. Dotted lines indicate helicopter flight path.

3.4 Current patterns

In Figure 14 the LANDSAT 2 registration (August 9, 1975 ID.2199-09351) shows the main mixing region of saltier North Sea water (ca 30 $^{o}/oo$) and Baltic water (ca 7 - 10 $^{o}/oo$). Information from the satellite indicates a possible inflow situation of water from the North Sea through the Öresund where the Baltic water is tagged by the blue-green algae in the surface. In this very complex current pattern the arrow indicates upwelling due to a coast-parallell winds (E≈4 m/sec.)

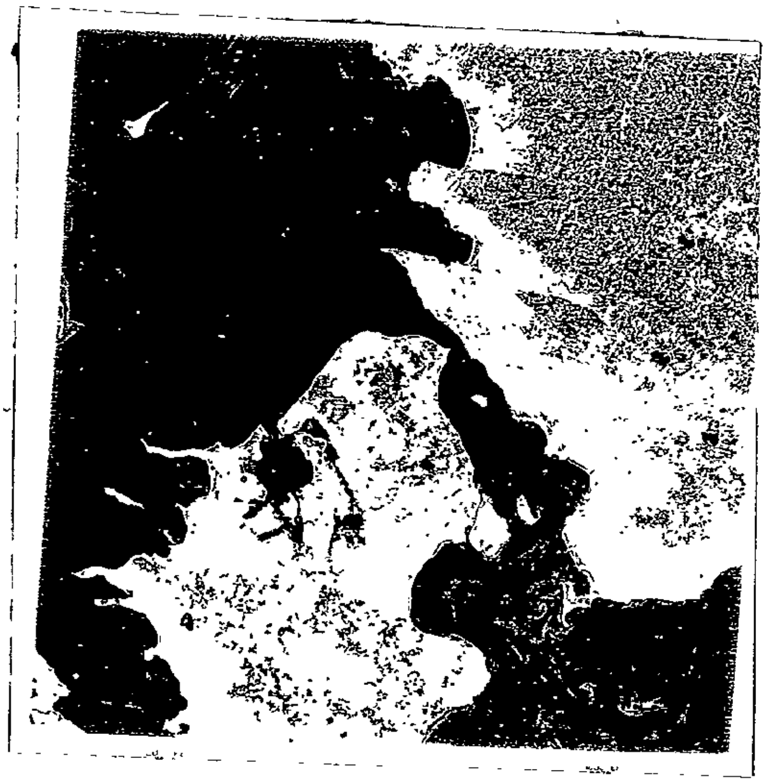


Figure 14 LANDSAT 2 registration (ID.2199-09351) August 9, 1975, showing a part of the main mixing area of the North Sea and Baltic waters. The streaks in the surface water are blue-green algae.

Figure 15 is a recording registered on August 6, 1975 (ID.2196-09183), over the southern part of the Baltic sea outside Poland. The structure in the surface water indicates heavy amounts of algae (see arrow) about 6 naut. miles from the coast and effluents from rivers point at a SW going coastal current.

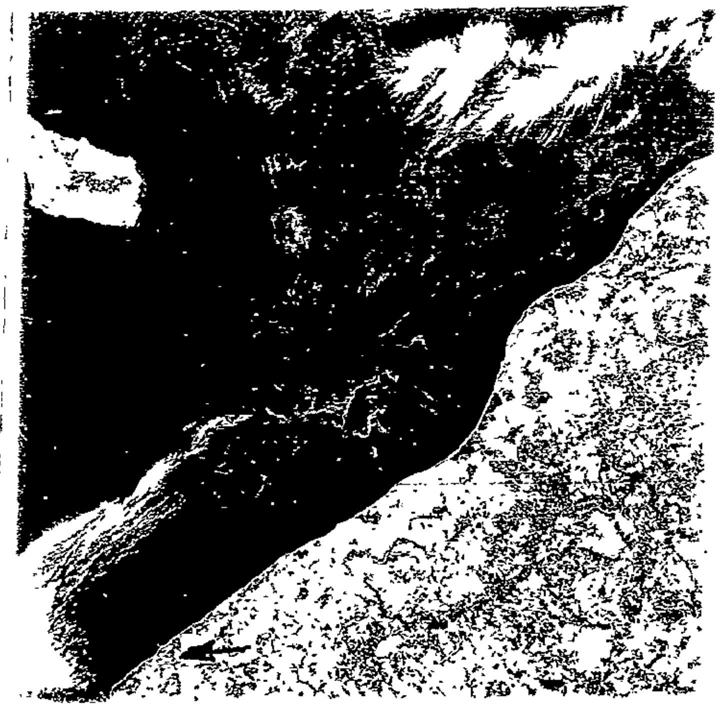


Figure 15. LANDSAT-2 registration August 6,1975 (ID.2196-09183) off-shore Poland. The configuration in the surface water is aggregation of blue-green algae. The arrow indicates the eff luent of the river Wisla.

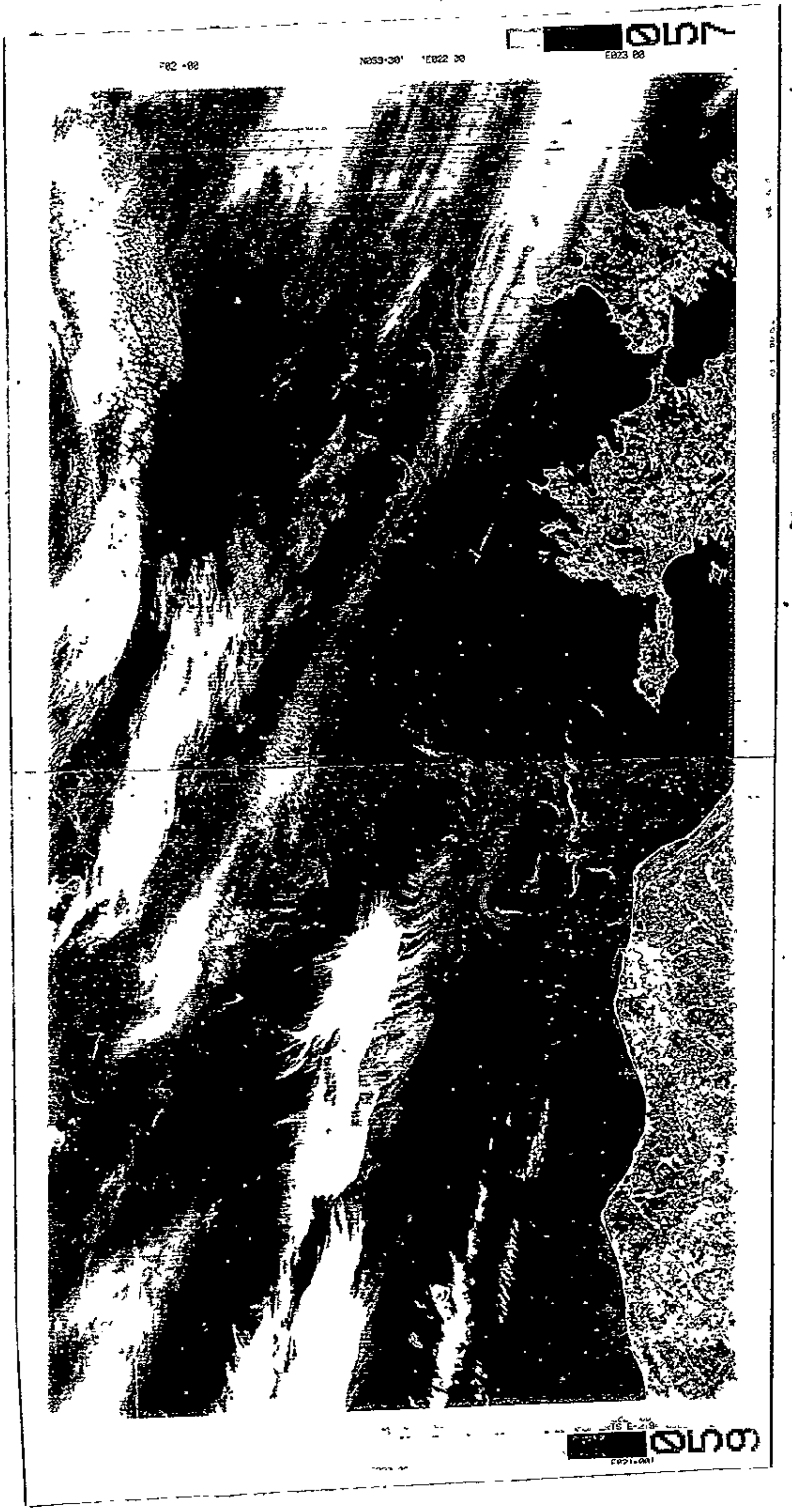


Figure 16. LANDSAT-2 registrations from August 4, 1975 (ID.2194-09062 and 2194-09055) of the Baltic Sea off-shore USSR, showing aggregations of blue-green algae in the surface water . The outflow of river Venta can also be noticed.

Figure 16 (August 4, 1975 ID.2194-09062 E 2194-09055) again shows a south going coastal current along the USSR coast and sharp streaks indicate the borders between the watermasses. The accumulations of algae beneath the cirrus clouds indicate a rather calm situation in the central part of the Baltic but the upper part indicates north going currents. Counter-clockwise gyres can be seen along the northern coast of the island of Saarema.

The last example of surface currents information obtained from LANDSAT 2 data is taken from the southern coast of Sweden Fig. 17. In this imagery from August 6 (ID.2196-09181) another counter-clockwise gyre is shown. Moreover there are indications of upwelling situations along the coast of Sweden and off the island of Öland due to N-NE winds. Sea truth measurements performed in the area to the lower left showing heavy streaks gave chlorophyll a values of 305 ug $l^{-1}$ and pheopigment of 399 ug $l^{-1}$, altogether $\approx$700 ug $l^{-1}$ chlorophyll a, compared to ca 0.5 - 1 ug $l^{-1}$ in a water column 0 - 6 m, which indicated a heavy aggregation near the surface.

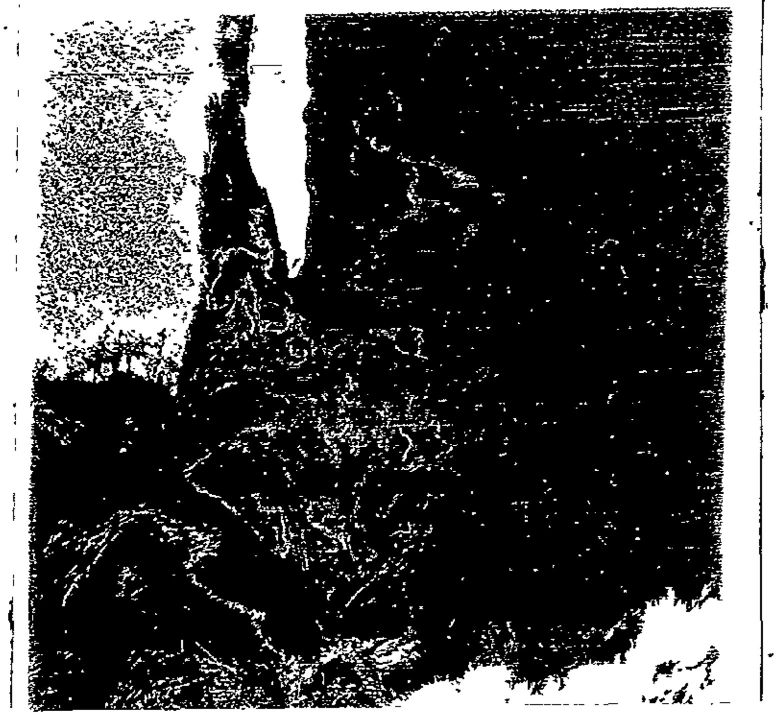


Figure 17. LANDSAT 2 registration August 6, 1975 (ID.2196-09181). The streaks in the surface water are blue-green algae showing a complex current pattern on the surface

There are to date few estimations of the role of nitrogen fixation of Nodularia (Brattberg 1974, Hübel and Hübel in print) and still fewer calculations of the total amounts of biomass and fixed nitrogen in the blooms (Nyqvist 1974, Öström 1976).

The trigger of the blooms are still obscure. They occur during the warmest part of the year and it is tempting to point to temperature as a major factor. Phosphate as an essential element for the alga could also indicate upwelling areas as nuclei for the blooms which during their surface floating phase could then be wind-driven (Jansson 1977). The assumed upwelling areas in Figs. 14 and 17 would then act as "nutrient windows" letting through bottom generated nutrients to the euphotic surface zone.

Another source of organic materials are the sewage plumes from rivers or urban areas. Quantification of the effluents, which have been registrated along the coasts of USSR, Poland and DDR have not been made because of difficulties in obtaining ground truth data. The whole of the Stockholm archipelago is dominated by the urban processes which ultimately show up as effects on the environment in increased chlorophyll and turbidity.

In order to measure the sedimentation rate of the sinking, dying algae during the declining phase of the bloom, sediment traps had been anchored in the northern part of the investigation area. Unfortunately none of these could be recovered, probably trapped by trawls or fishing nets in these international waters. Although therefore nothing can be said about the sedimentation of the registered bloom, previous experience has shown that a heavy fall-out from Nodularia exists and also reaches the bottom (Nyqvist in print). Due to the sensitivity of the deep basins to increased loads of organic matter this is of course of great interest where the decaying Nodularia material is deposited. This calls for an intensive survey of the blooms throughout their entire phase; more extensive than the 18 days upon which this investigation is based (Fig. 13).

4.2 The importance of large scale, synoptic quantifications.
Though water is a fluid medium this by no means secures a homogeneous distribution of its suspended solids neither living nor dead. Patchiness of plankton populations is a well known phenomenon in the oceans. For modelling of the pelagic systems and in order to give a true representation of such crucial problems as zooplankton grazing on phytoplankton the critical size of the plankton patches has to be determined This has up till now been done almost exclusively by measurements from ships, at best as continuous tracking with towed fluorimeters such as we in some cases employed (Fig. 3). Relying on a small number of fixed stations only - which is often the case due to lack of money - results in a high degree of uncertainty. The bloom might be concentrated in other parts of the sea.

To date, no information exists on large scale patterns of the Baltic plankton which makes a total quantification most uncertain.

4.3. Remote sensing as an operational technique.
The increasing need for large scale, synoptic surveys in the Baltic can only be met with through remote sensing technique. Though only a few successful sceneries could be obtained in the present investigation these results have already greatly enriched the Baltic environmental sciences and induced new sampling schemes. The bluegreen blooms appear as an even more important Baltic feature which will have to be monitored in the future. The remarkably good correlation between concentrations of chlorophyll a and LANDSAT-2 bands has presented us with a powerful tool with which to survey the archipelagos of the Baltic with regard to eutrophication processes. Using the <u>Nodularia</u> blooms as "tracer substances", current patterns can be studied and critical sizes of gyres and patches evaluated. The strait between Sweden and Denmark, the Öresund, also also recorded in the LANDSAT imagery reveals itself as a typical mixing area(Fig. 14).

4.4. Problems connected with the utilization of LANDSAT data.
One of the main drawbacks has been the late delivery of the data which in this case severely retarded the whole investigation. It is not known where in the process of information transfer this delay occurred but the first sceneries were to hand in July 1975 and in January 1976 the summer registrations from August 1975 were received. Also the final date of launching of LANDSAT-2 was for several weeks obscure which made a possible survey of the spring bloom of that year impossible.

Another complication has been the quality of the material. Due to either differences in the detector signals or in calibration the translation of the bands to digital maps was characterized by striping. This had to be compensated for by special smoothing techniques.

A great disappointment was also the lack of registration by LANDSAT-2 on the contracted sampling occasion, July 2 1975. It was intended to make this passage a primary test period incorporating ground truth data at sea with simultaneous registration of part of the area by a multi-spectral scanner as a part of a cooperative research study by Swedish and French space corporations. For some unknown reason the track of LANDSAT-2 at this period was deflected westward over the Swedish mainland and no registration of our test site was obtained.

The last complication has been the difficulty of obtaining expected financial support throughout the experiment which enforced the running of this project except for the support during data processing and sea truth sampling, with only one part-time scientist(B.N.) and which has resulted in the late presentation of the quarterly report and much of the data still unprocessed. A rough calculation of the total biomass of Nodularia blooms is yet to come for example but it is hoped that the method of processing the raw data will be even faster and easier.

4.5. Recommendations.

Although not especially adapted to aquatic use LANDSAT-2 has been of great use in assessing large scale pattterns of import ant marine variables. Our recommendations are concerned less with the LANDSAT functioning system than in advice to future utilizers. The striping of the tapes was certainly a drawback but should be easy to correct. Our main technical experience, however, concerns the handling of the obtained remote sensing products. The digital processing of the data, using the techniques, the reading instrument IRIS and programmes developed at the Image Processing Section of the Swedish National Defence Research Institute (see appendix) can be strongly recommended as a simple and fast technique. As stated in sect. 4.4. these instruments can produce far more sophisticated results and although the ground truth data does not allow more far-reaching conclusions, the results as they now stand constitute a considerable contribution to Baltic science.

In our opinion no single expression can be calculated for and ecological parameter such as chlorophyll which could be applied anytime and anywhere in the Baltic. The relation between satellite sea truth data has to be determined with reference to the existing phytoplankton population and other natural variations in living components during the biological year.

5. PUBLICATIONS

The results obtained so far have been published to a very small extent in anticipation of the criticism of this final draft report. ERTS-1 products, however have been used in several publications, for example Nyqvist 1974, Jansson 1977. In numerous talks and discussion we have used material both from LANDSAT-1 and LANDSAT-2 to exemplify the need for large scale synoptic quantifications of biologically active material.

Examples of such talks are:

First sub-regional Eastern-Mediterranean Modelling Workshop, Alexandria, 1975.

Third Soviet-Swedish Symposium on the control of the Baltic Sea Pollution, Stockholm, 1975.

Committee Meeting of the Baltic Marine Biologists, Gdansk, Poland, 1976.
Joint Soviet-Swedish Expert Meeting, Riga, USSR, 1976.

## 6. CONCLUSIONS

The specific objectives: 1. "To develop a technique for using a synoptic view to obtain basic ecological parameters ..." 2. "To develop an operational tool for monitoring the Baltic Sea ..." have in our opinion been successfully reached. Remote sensing technique as demonstrated by LANDSAT registrations can be strongly recommended for obtaining large scale patterns of phytoplankton blooms, chlorophyll concentrations, discharge plumes and surface current patterns in the Baltic area.

The present results have pointed to the phytoplankton patches as being of much greater scale than previously thought and have suggested new areas for both organic discharge and upwelling. The future sampling programmes will certainly concentrate on these findings.

## ACKNOWLEDGEMENTS

This investigation carried out as a joint effort to obtain synoptic information of large scale ecological parameters was only made possible due to generous help with sampling and transfer of data by our colleagues around the Baltic Sea to whom we extend our grateful thanks.
The Image Processing Section of the Swedish National Research Defence Research Institute are kindly acknowledged for making the CCT processing possible while thanks are due to the Visby Rescue Group, Swedish Air Force who made helicopter observations possible and also kindly provided an opportunity of following the changes in the bluegreen algal bloom during July/August.
Financial support for sea truth and data processing was given by the Swedish Environmental Protection Board and Swedish Delegation for Space Activities.

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# APPENDIX A.

APPENDIX A

## SEA TRUTH SAMPLING

Following institute participated in the experiment.

Area 1 - 4, Öresund

Department of Marine Botany
Mr Lars Edler
University of Lund
Sweden

Area 5, Arcona basin

Institute für Meereskunde
Dr S. Schultz
Warnemünde
DDR

Area 6, 7, Hanö Bay and E. Gotland

Fishery Board of Sweden
Mr O. Lindahl
Lysekil
Sweden

Area 8, North-western Baltic

Askö Laboratory
Mr Bo Nyqvist
University of Stockholm
Sweden

Area 9, Stockholm Archipelago

Stockholm Water and sewerage Works
Eng. M. Cronholm
Stockholm
Sweden

Institute of Plant Ecology
Mr G. Engström
University of Uppsala
Sweden

Area 10, Åland Sea

Husö Laboratory
Mr T. Lindholm
University of Åbo
Finland

Phytoplankton sampling in algal aggregations along the Swedish coast.

Swedish Meteorological and Hydrological Institute
Mr B. Broman
Norrköping
Sweden

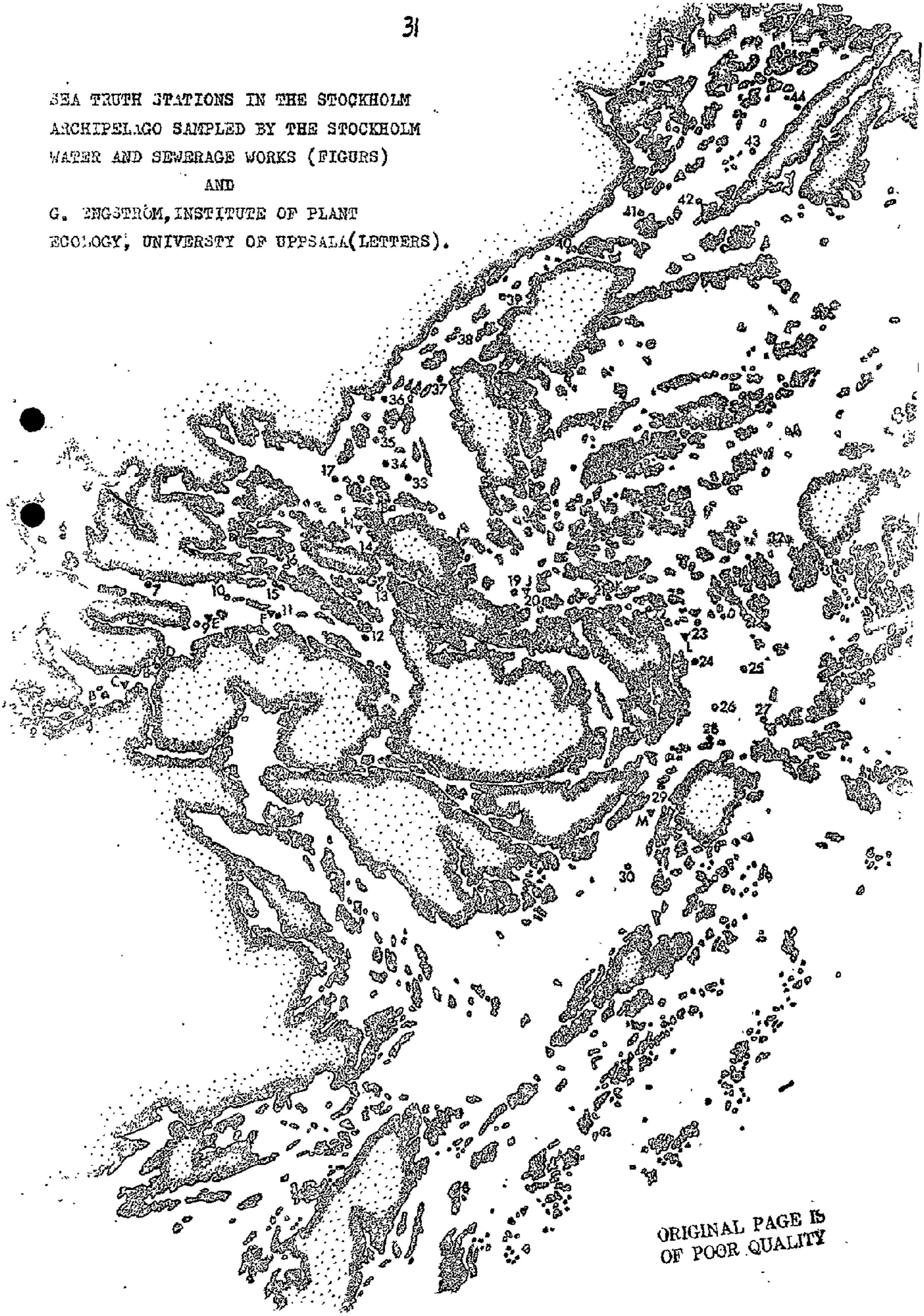
Swedish Coast Guard
Stockholm
Sweden

The following pages contain sea truth data used in this report.

SEA TRUTH STATIONS IN THE STOCKHOLM ARCHIPELAGO SAMPLED BY THE STOCKHOLM WATER AND SEWERAGE WORKS (FIGURS)

AND

G. ENGSTRÖM, INSTITUTE OF PLANT ECOLOGY, UNIVERSTY OF UPPSALA (LETTERS).



SEA TRUTH MEASUREMENTS SAMPLED

BY

STOCKHOLM WATER AND SEWERAGE WORKS
P.O. 6407
113 82 STOCKHOLM

# SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-14

STN: 1

| | | | |
|---|---|---|---|
| Temperature | 17.6 | 13.6 | 6.1 |
| S °/oo | .88 | 2.0 | 4.98 |
| $O_2$ mg/l | 8.9 (97) | 7.9 (79) | 4.4 (3 |
| $PO_4$-P ug/l | 3 | | |
| Tot-P " | 41 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | 8200 | 28000 | 15000 |
| Secchi disk (m) | 2.6 | | |

DATE: 1975-07-14

STN: 2

| | 0 m | 2 m | 10 m |
|---|---|---|---|
| Temperature | 15.2 | 14.2 | 6.4 |
| S °/oo | 2.05 | 3.39 | 5.01 |
| $O_2$ mg/l | 8.4 (87) | 9.0 (9.2) | 4.7 (4 |
| $PO_4$-P ug/l | | | |
| Tot.-P " | | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot.-N " | | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | 25000 | 8200 | 82000 |
| Secchi disk (m) | 2.3 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-14
STN: 3

| | 0 m | | 2 m | | 8 m | |
|---|---|---|---|---|---|---|
| Temperature | 15.4 | | 15.5 | | 8.8 | |
| S ‰ | 3.17 | | 3.44 | | 4.45 | |
| $O_2$ mg/l | 10.5 | (110) | 10.2 | (108) | 4.7 | (43) |
| $PO_4$-P ug/l | 1 | | | | 9 | |
| Tot-P " | 40 | | | | 43 | |
| $NH_4$-N " | 65 | | | | 440 | |
| $NO_2$-N " | 22 | | | | 5 | |
| $NO_3$-N " | 210 | | | | 585 | |
| Tot-N " | 840 | | | | 1220 | |
| Chl. a " | 32.2 | | 29.4 | | | |
| Tot Chl " | | | | | | |
| Coliform no/l | 4100 | | 3200 | | 2000 | |
| Secchi disk (m) | 1.8 | | | | | |

DATE: 1975-07-14
STN: 8

| | 0 m | | 2 m | | 8 m | |
|---|---|---|---|---|---|---|
| Temperature | 16.2 | | 15.9 | | 7.9 | |
| S ‰ | 3.41 | | 3.44 | | 4.90 | |
| $O_2$ mg/l | 11.3 | (121) | 11.0 | (117) | 4.5 | (40 |
| $PO_4$-P ug/l | 8 | | | | 20 | |
| Tot.-P " | 36 | | | | 46 | |
| $NH_4$-N " | 45 | | | | 240 | |
| $NO_2$-N " | 15 | | | | 24 | |
| $NO_3$-N " | 85 | | | | 515 | |
| Tot.-N " | 820 | | | | 1080 | |
| Chl. a " | 43.4 | | 47.2 | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | 1400 | | 3400 | | 700 | |
| Secchi disk (m) | 1.4 | | | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-15
STN: 13

| | 0 m | | 6 m | | 10 m | |
|---|---|---|---|---|---|---|
| Temperature | 17.5 | | 17.0 | | 9.0 | |
| S °/oo | 3.84 | | 3.89 | | 5.63 | |
| $O_2$ mg/l | 11.0 | (121) | 10.8 | (118) | 7.1 | (66) |
| $PO_4$-P ug/l | 12 | | | | | |
| Tot-P " | 28 | | | | | |
| $NH_4$-N " | 20 | | | | | |
| $NO_2$-N " | 1 | | | | | |
| $NO_3$-N " | 5 | | | | | |
| Tot-N " | 560 | | | | | |
| Chl. a " | 19.5 | | | | | |
| Tot Chl " | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 1.6 | | | | | |

DATE: 1975-07-15
STN: 14

| | 0 m | | 4 m | | 10 m | |
|---|---|---|---|---|---|---|
| Temperature | 17.4 | | 12.1 | | 11.6 | |
| S °/oo | 3.84 | | 3.95 | | 4.80 | |
| $O_2$ mg/l | 11.2 | (123) | 11.0 | (120) | 7.6 | (74) |
| $PO_4$-P ug/l | 2 | | 1 | | 3 | |
| Tot.-P " | 32 | | 29 | | 15 | |
| $NH_4$-N " | 10 | | 10 | | 70 | |
| $NO_2$-N " | 2 | | 1 | | 2 | |
| $NO_3$-N " | 5 | | 5 | | 10 | |
| Tot.-N " | 580 | | 560 | | 320 | |
| Chl. a " | | | | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 1.6 | | | | | |

## SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-15
STN: 17

| | 0 m | | 6 m | | 10 m | |
|---|---|---|---|---|---|---|
| Temperature | 16.6 | | 14.1 | | 11.2 | |
| S °/oo | 4.6 | | 4.87 | | 5.68 | |
| $O_2$ mg/l | 9.9 | (108) | 9.1 | (94) | 8.2 | (80 |
| $PO_4$-P ug/l | 1 | | 1 | | 1 | |
| Tot-P " | 23 | | 21 | | 12 | |
| $NH_4$-N " | | | | | | |
| $NO_2$-N " | | | | | | |
| $NO_3$-N " | | | | | | |
| Tot-N " | | | | | | |
| Chl. a " | 8.4 | | | | | |
| Tot Chl " | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 2.6 | | | | | |

DATE: 1975-07-15
STN: 18

| | 0 m | | 6 m | | 8 m | |
|---|---|---|---|---|---|---|
| Temperature | 17.1 | | 15.4 | | 12.5 | |
| °/oo | 4.74 | | 5.19 | | 5.72 | |
| $O_2$ mg/l | 10.3 | (113) | 9.3 | (99) | 8.8 | (88) |
| $PO_4$-P ug/l | 1 | | 1 | | 1 | |
| Tot-P " | 25 | | 21 | | 14 | |
| $NH_4$-N " | 10 | | | | | |
| $NO_2$-N " | | | | | | |
| $NO_3$-N " | 5 | | | | | |
| Tot.-N " | 380 | | | | | |
| Chl. a " | 9.3 | | | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 3.3 | | | | | |

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OF POOR QUALITY

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-15
STN: 19

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 17.5 | | |
| S ‰ | 4.78 | | |
| $O_2$ mg/l | 10.9 (121) | | |
| $PO_4$-P ug/l | 2 | | |
| Tot-P " | 21 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 3.0 | | |

DATE: 1975-07-15
STN: 20

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 17.5 | | |
| S ‰ | 5.10 | | |
| $O_2$ mg/l | 10.4 (115) | | |
| $PO_4$-P ug/l | 1 | | |
| Tot.-P " | 23 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot.-N " | | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 4.0 | | |

## SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-15

STN: 22

| | | | |
|---|---|---|---|
| Temperature | 17.2 | 13.9 | 11.3 |
| S °/oo | 5.26 | 5.88 | 6.00 |
| $O_2$ mg/l | 10.5 (116) | 9.6 (99) | 9.1 (8 |
| $PO_4$-P ug/l | 1 | 3 | 4 |
| Tot-P " | 23 | 15 | 15 |
| $NH_4$-N " | 10 | 15 | 15 |
| $NO_2$-N " | – | – | – |
| $NO_3$-N " | 5 | 5 | 5 |
| Tot-N " | 390 | 270 | 230 |
| Chl. a " | 6.6 | | |
| Tot Chl " | – | | |
| Coliform no/l | – | | |
| Secchi disk (m) | 3.7 | | |

DATE: 1975-07-15

STN: 23

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 16.1 | 15.6 | 12.4 |
| S °/oo | 5.82 | 5.91 | 5.88 |
| $O_2$ mg/l | 10.2 (110) | 10.0 (107) | 9.6 (96) |
| $PO_4$-P ug/l | 2 | 1 | 3 |
| Tot.-P | 14 | 12 | 12 |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot.-N " | | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 5.9 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-16

STN: 24

| | 0 m | | 6 m | 12 m |
|---|---|---|---|---|
| Temperature | 15.7 | | | |
| S $^o/oo$ | 5.9 | | | |
| $O_2$ mg/l | 9.9 | (106) | | |
| $PO_4$-P ug/l | 5 | | | |
| Tot.-P " | 13 | | | |
| $NH_4$-N " | | | | |
| $NO_2$-N " | | | | |
| $NO_3$-N " | | | | |
| Tot.-N " | | | | |
| Chl. a " | | | | |
| Tot Chl." | | | | |
| Coliform no/l | | | | |
| Secchi disk (m) | 7.0 | | | |

DATE:

STN:

| | |
|---|---|
| Temperature | |
| S $^o/oo$ | |
| $O_2$ mg/l | |
| $PO_4$-P ug/l | |
| Tot-P " | |
| $NH_4$-N " | |
| $NO_2$-N " | |
| $NO_3$-N " | |
| Tot-N " | |
| Chl. a " | |
| Tot Chl " | |
| Coliform no/l | |
| Secchi disk (m) | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-16

STN: 25

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 15.2 | | |
| S ‰ | 5.93 | | |
| $O_2$ mg/l | 9.9 (105) | | |
| $PO_4$-P ug/l | 3 | | |
| Tot.-P " | 12 | | |
| $NH_4$-N " | 15 | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | 5 | | |
| Tot.-N " | 210 | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 7.7 | | |

DATE: 1975-07-16

STN: 27

| | 0 m | 12 m | 14 m |
|---|---|---|---|
| Temperature | 15.2 | 14.9 | |
| S ‰ | 6.04 | 6.06 | |
| $O_2$ mg/l | 9.9 (105) | 9.7 (103) | |
| $PO_4$-P ug/l | 2 | 2 | |
| Tot.-P " | 14 | 13 | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot.-N " | | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 8.0 | | |

SEA TRUTH DATA, STOCKHOLM [illegible]

DATE: 1975-07-16

STN: 29

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 16 | | |
| S $^{o}/oo$ | 6.0 | | |
| $O_2$ mg/l | | | |
| $PO_4$-P ug/l | 2 | | |
| Tot-P " | 13 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | 2.2 | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 7.0 | | |

DATE: 1975-07-16

STN: 30

| | 0 m | 10 m | 12 m |
|---|---|---|---|
| Temperature | 15.8 | 15.7 | |
| S $^{o}/oo$ | 6.04 | 6.06 | |
| $O_2$ mg/l | 9.9 (107) | 9.8 (105) | |
| $PO_4$-P ug/l | 1 | 1 | |
| Tot.-P " | 14 | 14 | |
| $NH_4$-N " | 10 | | |
| $NO_2$-N " | – | | |
| $NO_3$-N " | 5 | | |
| Tot.-N " | 260 | | |
| Chl. a " | 2.3 | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 7 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-16
STN: 31

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 16.3 | 16.2 | 13.0 |
| S °/oo | 5.86 | 5.95 | 6.13 |
| $O_2$ mg/l | 10.1 (110) | 9.7 (105) | - |
| $PO_4$-P ug/l | 1 | 1 | 3 |
| Tot-P " | 14 | 15 | 12 |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | 2.4 | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 6.7 | | |



DATE: 1975-07-16
STN: 32

| | 0 m | 10 m | 12 m |
|---|---|---|---|
| Temperature | 16.3 | 14.9 | |
| S °/oo | 5.79 | 5.99 | |
| $O_2$ mg/l | 9.9 (108) | 9.6 (101) | |
| $PO_4$-P ug/l | 2 | 2 | |
| Tot-P " | 12 | 13 | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | 2.8 | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 6.3 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-17

STN: 35

| | 0 m | 6 m | 10 m |
|---|---|---|---|
| Temperature | 17.6 | | |
| S °/oo | 4.76 | | |
| $O_2$ mg/l | 9.9 (110) | | |
| $PO_4$-P ug/l | 2 | | |
| Tot-P " | 19 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 3.0 | | |

DATE: 1975-07-17

STN: 36

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 17.4 | | |
| S °/oo | 4.80 | | |
| $O_2$ mg/l | 9.7 (107) | | |
| $PO_4$-P ug/l | 3 | | |
| Tot-P " | 21 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | 2.5 | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-17

STN: 37

| | 0 m | | 6 m | | 17 m | |
|---|---|---|---|---|---|---|
| Temperature | 17.5 | | 16.6 | | 11.8 | |
| S °/oo | 4.83 | | 5.14 | | 5.44 | |
| $O_2$ mg/l | 9.7 | (107) | 8.3 | (90) | 7.7 | (76) |
| $PO_4$-P ug/l | 2 | | 1 | | 1 | |
| Tot.-P " | 22 | | 20 | | 17 | |
| $NH_4$-N " | | | | | | |
| $NO_2$-N " | | | | | | |
| $NO_3$-N " | | | | | | |
| Tot.-N " | | | | | | |
| Chl. a " | 8.9 | | | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 2.9 | | | | | |

DATE: 1975-07-15

STN: 38

| | 0 m | | 6 m | 12 m |
|---|---|---|---|---|
| Temperature | 17.7 | | | |
| S °/oo | 4.81 | | | |
| $O_2$ mg/l | 9.6 | (107) | | |
| $PO_4$-P ug/l | 1 | | | |
| Tot.-P " | 16 | | | |
| $NH_4$-N " | | | | |
| $NO_2$-N " | | | | |
| $NO_3$-N " | | | | |
| Tot.-N " | | | | |
| Chl. a " | 3.7 | | | |
| Tot Chl." | | | | |
| Coliform no/l | | | | |
| Secchi disk (m) | 2.9 | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 197507-17
STN: 39

| | 0 m | | 4 m | | 8 m | |
|---|---|---|---|---|---|---|
| Temperature | 17.5 | | 16.1 | | 12.6 | |
| S °/oo | 4.85 | | 5.03 | | 5.55 | |
| $O_2$ mg/l | 9.7 | (107) | 9.1 | (98) | 7.4 | (74) |
| $PO_4$-P ug/l | 1 | | 1 | | 1 | |
| Tot-P " | 20 | | 15 | | 17 | |
| $NH_4$-N " | 10 | | 10 | | 15 | |
| $NO_2$-N " | | | | | | |
| $NO_3$-N " | 5 | | 5 | | 5 | |
| Tot-N " | 370 | | 330 | | 260 | |
| Chl. a " | 6.9 | | | | | |
| Tot Chl " | | | | | | |
| Coliform no/l | 2.5 | | | | | |
| Secchi disk (m) | | | | | | |

DATE: 1975-07-17
STN: 40

| | 0 m | | 6 m | 12 m |
|---|---|---|---|---|
| Temperature | 17.7 | | | |
| S °/oo | 4.81 | | | |
| $O_2$ mg/l | 9.7 | (108) | | |
| $PO_4$-P ug/l | 2 | | | |
| Tot.-P " | 21 | | | |
| $NH_4$-N " | | | | |
| $NO_2$-N " | | | | |
| $NO_3$-N " | | | | |
| Tot.-N " | | | | |
| Chl. a " | | | | |
| Tot Chl." | | | | |
| Coliform no/l | | | | |
| Secchi disk (m) | 2.7 | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-17

STN: 41

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 17.2 | | |
| S °/oo | 4.89 | | |
| $O_2$ mg/l | 9.6 (106) | | |
| $PO_4$-P ug/l | 2 | | |
| Tot-P " | 18 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 3.0 | | |

DATE: 1975-07-17

STN: 42

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 16.1 | | |
| S °/oo | 5.32 | | |
| $O_2$ mg/l | 9.5 (103) | | |
| $PO_4$-P ug/l | 1 | | |
| Tot.-P " | 18 | | |
| $NH_4$-N " | 10 | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | 5 | | |
| Tot.-N " | 210 | | |
| Chl. a " | 4.2 | | |
| Tot Chl." | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 3.8 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-07-17
STN: 43

| | 0 m | 6 m | 12 m |
|---|---|---|---|
| Temperature | 16.1 | | |
| S $^o/_{oo}$ | 5.34 | | |
| $O_2$ mg/l | 9.4 (101) | | |
| $PO_4$-P ug/l | 1 | | |
| Tot-P " | 19 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 3.8 | | |

DATE: 1975-07-17
STN: 44

| | 0 m | 6 m | 10 m |
|---|---|---|---|
| Temperature | 16.6 | | |
| S $^o/_{oo}$ | 5.39 | | |
| $O_2$ mg/l | 9.5 (104) | | |
| $PO_4$-P ug/l | 1 | | |
| Tot-P " | 19 | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | | | |
| Secchi disk (m) | 4.1 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-08-04

STN: 3

| | 0 m | | 2 m | | 6 m | |
|---|---|---|---|---|---|---|
| Temperature | 18.0 | | 16.7 | | 11.8 | |
| S $^o/oo$ | 2.12 | | 2.95 | | 3.95 | |
| $O_2$ mg/l | 10.6 | (117) | 10.2 | (110) | 6.5 | (63) |
| $PO_4$-P ug/l | 3 | | | | 5 | |
| Tot.-P " | 39 | | | | 55 | |
| $NH_4$-N " | 35 | | | | 25 | |
| $NO_2$-N " | 10 | | | | 12 | |
| $NO_3$-N " | 165 | | | | 415 | |
| Tot.-N " | 700 | | | | 800 | |
| Chl. a " | 22.0 | | 28.3 | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | 600 | | 400 | | 2200 | |
| Secchi disk (m) | 1.8 | | | | | |

DATE: 1975-08-04

STN: 4

| | 0 m | | 2 m | | 6 m |
|---|---|---|---|---|---|
| Temperature | 20.6 | | 19.5 | | 11.2 |
| S $^o/oo$ | 3.42 | | 3.68 | | 4.56 |
| $O_2$ mg/l | 13.5 | (157) | 12.8 | (146) | |
| $PO_4$-P ug/l | 3 | | | | |
| Tot-P " | 41 | | | | |
| $NH_4$-N " | 260 | | | | |
| $NO_2$-N " | 4 | | | | |
| $NO_3$-N " | 1 | | | | |
| Tot-N " | 500 | | | | |
| Chl. a " | 28.3 | | 31.9 | | |
| Tot Chl " | | | | | |
| Coliform no/l | 100 | | 200 | | 1100 |
| Secchi disk (m) | 1.1 | | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-08-04

STN: 5

| | 0 m | | 4 m | | 8 m | |
|---|---|---|---|---|---|---|
| Temperature | 21.0 | | 18.2 | | 11.4 | |
| S $^{o}/_{oo}$ | 3.84 | | 3.93 | | 4.60 | |
| $O_2$ mg/l | 12.9 | (152) | 13.0 | (151) | 2.9 | (28) |
| $PO_4$-P ug/l | | | | | | |
| Tot.-P " | | | | | | |
| $NH_4$-N " | | | | | | |
| $NO_2$-N " | | | | | | |
| $NO_3$-N " | | | | | | |
| Tot.-N " | | | | | | |
| Chl. a " | | | | | | |
| Tot. Chl." | | | | | | |
| Coliform no/l | 50 | | 50 | | 50 | |
| Secchi disk (m) | 1.3 | | | | | |

DATE: 1975-08-04

STN: 6

| | 0 m | | 2 m | | 10 m | |
|---|---|---|---|---|---|---|
| Temperature | 20.8 | | 19.8 | | 8.4 | |
| S $^{o}/_{oo}$ | 3.95 | | 3.95 | | 5.30 | |
| $O_2$ mg/l | 11.9 | (140) | 12.3 | (142) | 1.2 | (11) |
| $PO_4$-P ug/l | 3 | | | | | |
| Tot-P " | 38 | | | | | |
| $NH_4$-N " | 185 | | | | | |
| $NO_2$-N " | 6 | | | | | |
| $NO_3$-N " | 1 | | | | | |
| Tot-N " | 600 | | | | | |
| Chl. a " | 18.6 | | 16.7 | | | |
| Tot Chl " | | | | | | |
| Coliform no/l | | | | | | |
| Secchi disk (m) | 2.1 | | | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-08-04

STN: 7

| | 0 m | 2 m | 8 m |
|---|---|---|---|
| Temperature | 21.1 | 19.7 | 11.7 |
| S $^{o}/oo$ | 4.09 | 4.07 | 4.52 |
| $O_2$ mg/l | 11.9 (140) | 12.2 (140) | 6.5 (64) |
| $PO_4$-P ug/l | 5 | | 1 |
| Tot.-P " | 28 | | 28 |
| $NH_4$-N " | 165 | | 50 |
| $NO_2$-N " | 3 | | 13 |
| $NO_3$-N " | 1 | | 300 |
| Tot.-N " | 550 | | 450 |
| Chl. a " | 17.0 | 12.7 | |
| Tot Chl." | | | |
| Coliform no/l | 50 | | |
| Secchi disk (m) | 3.0 | | |

DATE: 1975-08-04

STN: 9

| | 0 m | 2 m | 10 m |
|---|---|---|---|
| Temperature | 20.4 | 17.4 | 8.1 |
| S $^{o}/oo$ | 3.80 | 3.84 | 4.80 |
| $O_2$ mg/l | 12.9 (150) | 12.2 (135) | 5.0 (45) |
| $PO_4$-P ug/l | | | |
| Tot-P " | | | |
| $NH_4$-N " | | | |
| $NO_2$-N " | | | |
| $NO_3$-N " | | | |
| Tot-N " | | | |
| Chl. a " | | | |
| Tot Chl " | | | |
| Coliform no/l | 50 | 200 | 600 |
| Secchi disk (m) | 1.5 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-08-04

STN: 10

| | 0 m | 6 m | 10 m |
|---|---|---|---|
| Temperature | 20.2 | | |
| S $^{o}/oo$ | 9.98 | | |
| $O_2$ mg/l | 12.3 (143) | | |
| $PO_4$-P ug/l | 4 | | |
| Tot.-P " | 32 | | |
| $NH_4$-N " | 85 | | |
| $NO_2$-N " | 4 | | |
| $NO_3$-N " | 1 | | |
| Tot.-N " | 400 | | |
| Chl. a " | | | |
| Tot Chl." | | | |
| Coliform no/l | c 50 | | |
| Secchi disk (m) | 1.4 | | |

DATE: 1975-08-04

STN: 11

| | 0 m | 2 m | 6 m |
|---|---|---|---|
| Temperature | 20.9 | 18.7 | 15.1 |
| S $^{o}/oo$ | 4.06 | 4.07 | 4.36 |
| $O_2$ mg/l | 12.5 (147) | 12.1 (137) | 8.6 (90) |
| $PO_4$-P ug/l | 4 | | |
| Tot-P " | 31 | | |
| $NH_4$-N " | 165 | | |
| $NO_2$-N " | 4 | | |
| $NO_3$-N " | 1 | | |
| Tot-N " | 650 | | |
| Chl. a " | 21.3 | 21.2 | |
| Tot Chl " | | | |
| Coliform no/l | 50 | 50 | 50 |
| Secchi disk (m) | 1.5 | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO

DATE: 1975-08-04

STN: 16

| | 0 m | | 2 m | | 6 m | |
|---|---|---|---|---|---|---|
| Temperature | 20.7 | | 19.0 | | 15.5 | |
| S °/oo | 4.24 | | 4.24 | | 4.40 | |
| $O_2$ mg/l | 11.0 | (129) | 10.8 | (123) | 8.4 | (89) |
| $PO_4$-P ug/l | 4 | | | | | |
| Tot.-P " | 28 | | | | | |
| $NH_4$-N " | 50 | | | | | |
| $NO_2$-N " | 4 | | | | | |
| $NO_3$-N " | 3 | | | | | |
| Tot.-N " | 400 | | | | | |
| Chl. a " | 12.4 | | 12.8 | | | |
| Tot Chl." | | | | | | |
| Coliform no/l | 50 | | 50 | | 50 | |
| Secchi disk (m) | 2.0 | | | | | |

SEA TRUTH MEASUREMENTS SAMPLED

BY

Mr. G. ENGSTRÖM

INSTITUTE of PLANT ECOLOGY

UNIVERSITY of UPPSALA

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO.

DATE: 1975-07-16

| Stn. | Chl.a | Secchi | Abs. 480 |
|---|---|---|---|
| A | 19 | 2.3 | .143 |
| B | 23 | 2.0 | .174 |
| C | 28 | 1.9 | .221 |
| D | 27 | 1.8 | .233 |
| E | 29 | 1.6 | .297 |
| F | 28 | 1.4 | .310 |
| G | 27 | 1.5 | .343 |
| H | — | — | .278 |
| I | 11 | 2.7 | .119 |
| J | 11 | 2.7 | .135 |
| K | 7 | 3.4 | .067 |
| L | 2 | 6.0 | |
| M | | | |

SEA TRUTH DATA, STOCKHOLM ARCHIPELAGO.

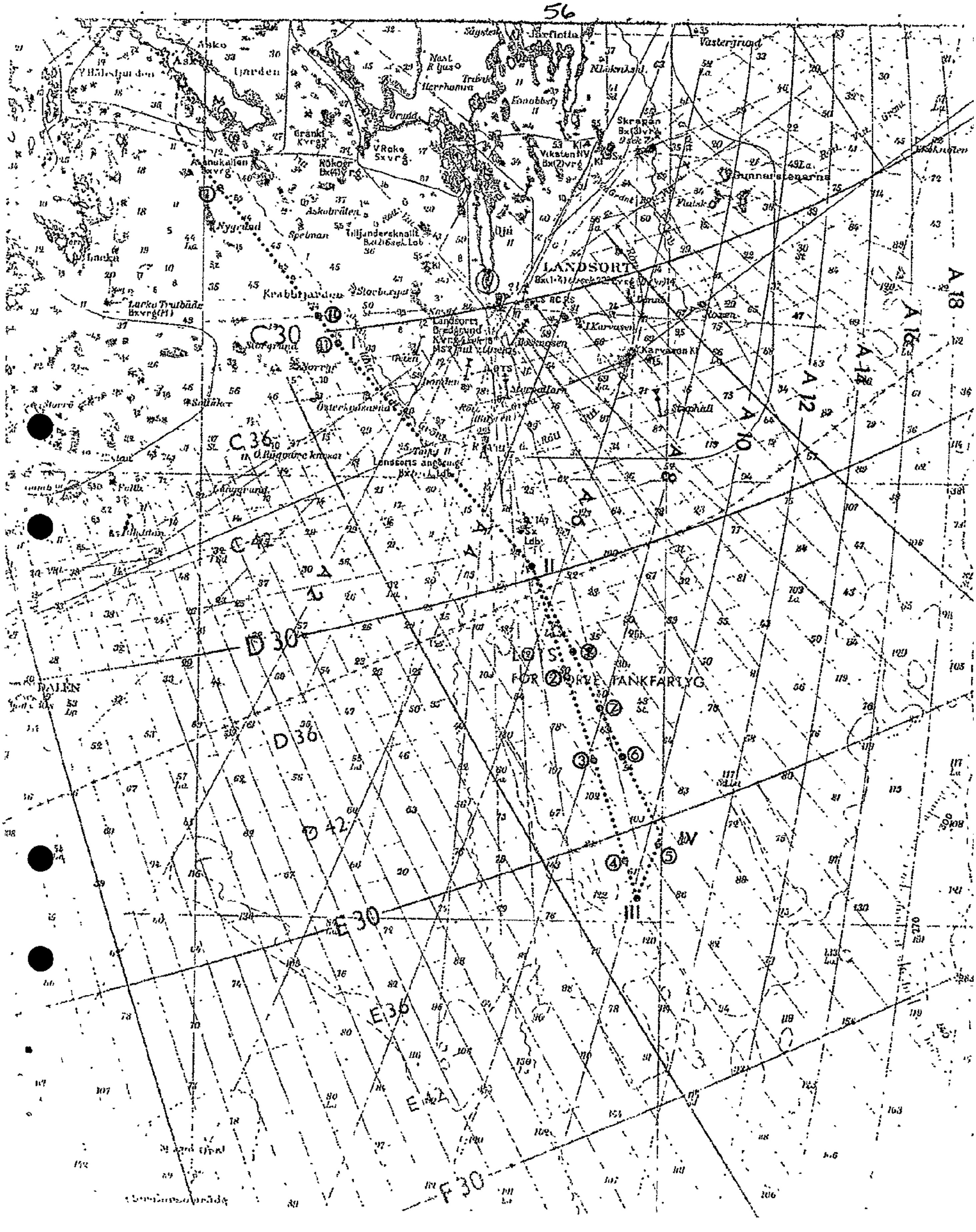
DATE: 1975-07-31

| Stn. | Chl.a | Secchi | Abs. 480 |
|---|---|---|---|
| A | 8 | 2.6 | .070 |
| B | 22 | 1.3 | .140 |
| C | — | — | — |
| D | 33 | 1.3 | .262 |
| E | 28 | 1.6 | .248 |
| F | 13 | 1.8 | .137 |
| G | 11 | 2.0 | .123 |
| H | 7 | 2.6 | .082 |
| I | 4 | 3.0 | .037 |
| J | 4 | 3.0 | .033 |
| K | 2 | 4.1 | .012 |
| L | 1 | 5.6 | .010 |
| M | 2 | 6.1 | .016 |

SEA TRUTH MEASUREMENTS SAMPLED

BY

ASKÖ LABORATORY

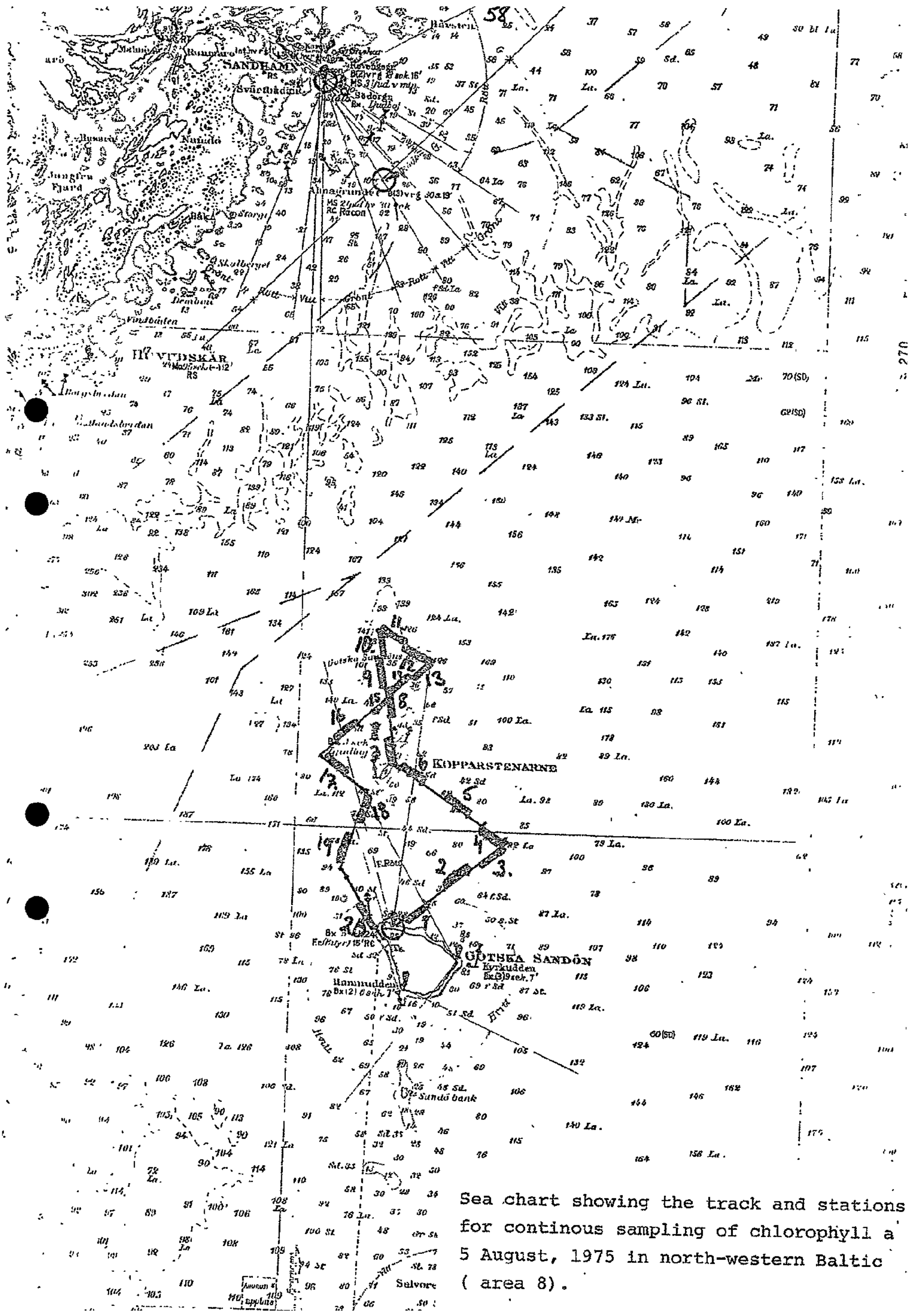



Sea chart over the North-Western Baltic (area 8) showing the track for continuos measure of chlorophyll a (dotted line) and fixed sampling stations(figures). July 20,1975.

SEA TRUTH, THE BALTIC SEA, S. LANDSORT.

DATE. 1975-07-20

| Stn. | | So/oo | Tot.Chl (ug/1) | Chl.a | Secchi (m) | Phytoplankton $u^3 10^6/1$ Tot. | blue-greens | monads | diatomees dinoflag. |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2.4 | 1.7 | | | | | |
| | 2 | | 1.4 | 1.1 | | | | | |
| | 3 | | 1.5 | 1.1 | | | | | |
| | 4 | | 3.0 | 2.1 | | | | | |
| | 5 | | 2.8 | 2.0 | | | | | |
| | 6 | | 1.8 | 1.2 | | | | | |
| | 7 | | 1.9 | 1.4 | | | | | |
| | 8 | | 1.6 | 1.0 | | | | | |
| | 9 | | | | | | | | |
| | 10 | 6.4 | | .8 | 6.3 | 287 | 155 | 95 | 3 |
| | 11 | 6.4 | 1.3 | .8 | 7.3 | 449 | 301 | 126 | 32 |
| Stn. | I | 6.3 | 3.3 | .8 | 7.3 | 177 | 100 | 77 | 11 |
| " | II | 6.4 | 2.5 | 1.6 | | 821 | 696 | 73 | 52 |
| " | III | 6.7 | 2.7 | 2.0 | 6.5 | 1160 | 1065 | 48 | 47 |
| " | IV | 6.7 | 7.5 | 6.4 | 6.3 | 3953 | 3777 | 102 | 74 |

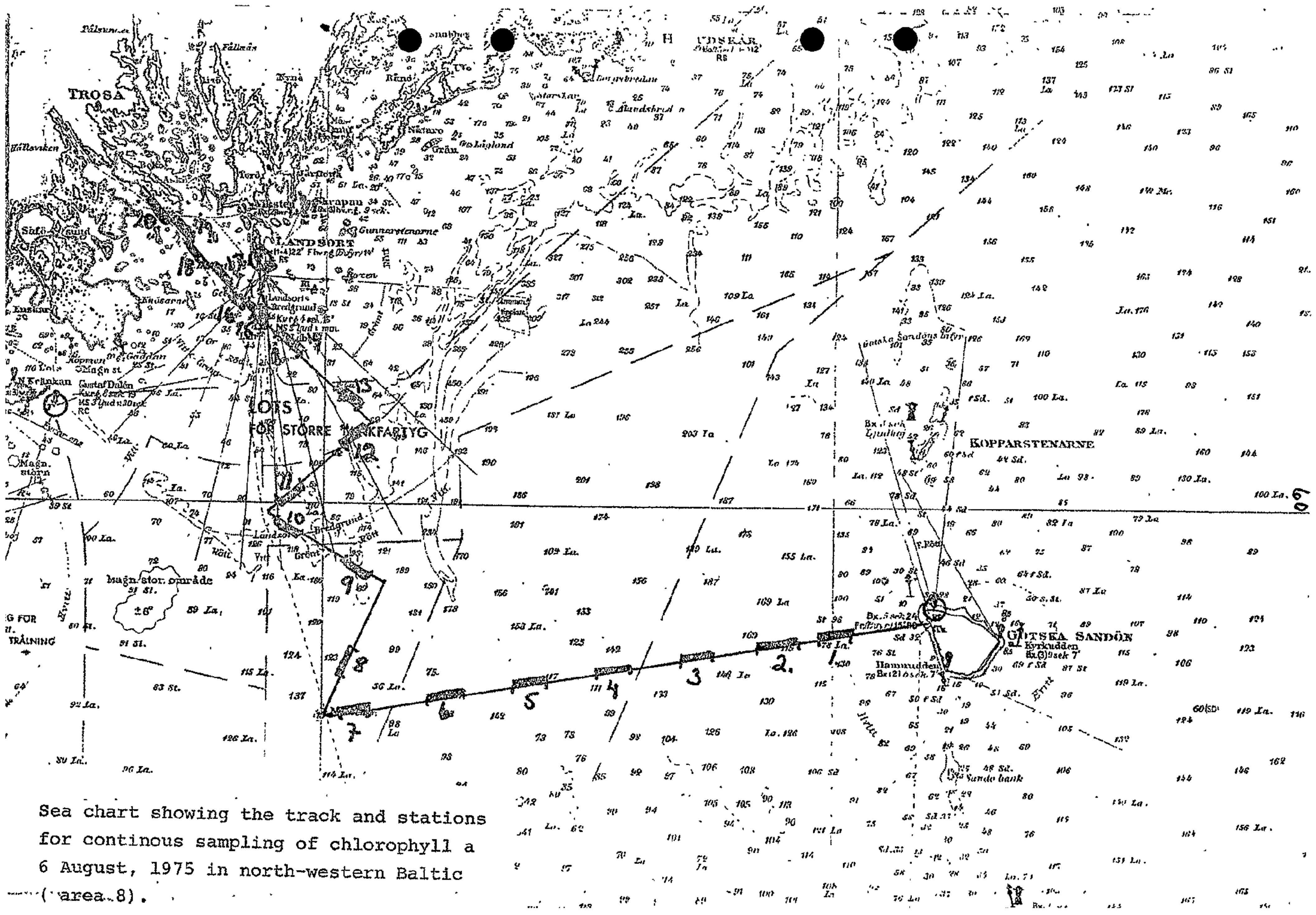



Sea chart showing the track and stations for continous sampling of chlorophyll a 5 August, 1975 in north-western Baltic ( area 8).

SEA TRUTH, THE BALTIC SEA, S. LANDSORT.

DATE: 1975-08-05

| Stn. | S o/oo | tot. chl. | chl a | Secchi | Phytoplankton | | | |
|---|---|---|---|---|---|---|---|---|
| | | ( ug/l) | | (m) | ( $u^3$ $10^6$ / l) | | | |
| | | | | | tot. | blue-greens | monads | diatomeés dinoflag. |
| 1 | 6.47 | 1.3 | .6 | 8.8 | 117 | 14 | 90 | 13 |
| 2 | 6.47 | .8 | .4 | | 143 | 38 | 100 | 5 |
| 3 | 6.37 | .8 | .4 | | 112 | 11 | 98 | 3 |
| 4 | 6.47 | .7 | .3 | 9.2 | 61 | 14 | 46 | 1 |
| 5 | 6.44 | 1.3 | .6 | | 89 | 13 | 71 | 5 |
| 6 | 6.47 | | | 9.2 | 120 | 22 | 97 | 1 |
| 7 | 6.47 | 2.1 | .9 | 6.5 | 143 | 36 | 98 | 8 |
| 8 | 6.33 | .9 | .5 | | 145 | 26 | 121 | 15 |
| 9 | 6.18 | .8 | .5 | 8.6 | 151 | 16 | 131 | 4 |
| 10 | 6.04 | 1.3 | .6 | | 178 | 23 | 154 | 2 |
| 11 | 6.01 | 1.3 | .6 | 6.8 | 191 | 86 | 100 | 5 |
| 12 | 5.86 | 1.4 | .8 | | 359 | 92 | 252 | 15 |
| 13 | 5.89 | 1.4 | .9 | 6.0 | 307 | 44 | 250 | 13 |
| 14 | 5.92 | 1.5 | .9 | | 298 | 54 | 232 | 12 |
| 15 | 6.15 | .8 | .6 | 9.0 | 133 | 23 | 103 | 6 |
| 16 | 6.47 | | | | 206 | 77 | 124 | 5 |
| 17 | 6.19 | 1.0 | .6 | 8.4 | 180 | 24 | 155 | 7 |
| 18 | 6.47 | | | 8.2 | 164 | 15 | 146 | 3 |
| 19 | 6.47 | 1.0 | .5 | | 142 | 4 | 136 | 2 |
| 20 | 6.47 | 1.1 | .7 | | 150 | 14 | 132 | 4 |




Sea chart showing the track and stations for continous sampling of chlorophyll a 6 August, 1975 in north-western Baltic (area 8).

SEA TRUTH, THE BALTIC SEA, S. LANDSORT.

DATE: 1975-08-06

| Stn. | S o/oo | tot.Chl. (ug/l) | Chl.a (ug/l) | Secchi (m) | Phytoplankton $u^3$ $10^6$ / l tot. | blue-greens | monads | diatomeés dinoflag. |
|---|---|---|---|---|---|---|---|---|
| 1 | 6.56 | .4 | .4 | 9.3 | 95 | 16 | 76 | 3 |
| 2 | 6.58 | .9 | .7 | 8.8 | 276 | 5 | 263 | 8 |
| 3 | 6.58 | .4 | .4 | 9.0 | 78 | 7 | 70 | 1 |
| 4 | 6.68 | .6 | .5 | 9.0 | 154 | 19 | 129 | 6 |
| 5 | 6.74 | 1.2 | .6 | | 163 | 39 | 120 | 4 |
| 6 | 6.58 | .7 | .5 | 9.7 | 173 | 11 | 158 | 3 |
| 7 | 6.88 | .5 | .4 | 10.5 | 107 | 14 | 87 | 5 |
| 8 | 6.85 | .6 | .3 | | 160 | 1 | 145 | 13 |
| 9 | 6.88 | .4 | .3 | 9.1 | 111 | 10 | 95 | 5 |
| 10 | 6.75 | .6 | .5 | 9.6 | 164 | 1 | 154 | 9 |
| 11 | 6.75 | .7 | .5 | 9.6 | 124 | 16 | 104 | 4 |
| 12 | 6.40 | .7 | .7 | 8.8 | 151 | 18 | 129 | 3 |
| 13 | 6.38 | 1.4 | .7 | 8.8 | 145 | 8 | 132 | 5 |
| 14 | 6.44 | 1.6 | 1.2 | 6.0 | 300 | 48 | 227 | 25 |
| 15 | 6.47 | 1.2 | .9 | 6.0 | 229 | 50 | 147 | 31 |
| 16 | 6.40 | 1.6 | 1.1 | | 389 | 46 | 281 | 62 |
| 17 | 6.38 | 1.9 | 1.2 | | 301 | 54 | 131 | 26 |
| 18 | 6.40 | 2.3 | 1.3 | | 466 | 51 | 365 | 50 |
| 19 | 6.44 | 2.3 | 1.1 | | 384 | 44 | 317 | 23 |
| 20 | 6.47 | 1.7 | 1.0 | | 438 | 27 | 319 | 92 |

# APPENDIX B

# IRIS - A TWO AXIS COMPARATOR AND MICRODENSITOMETER USING TWO DIFFERENT SCANNING MODES

N. Åslund, N. von Gersdorff, R. Norberg and J.A. Nordin
Physics IV, Royal Institute of Technology,
100 44 STOCKHOLM 70

ABSTRACT. IRIS (Image Reading Instrument System), built by SAAB-SCANIA in cooperation with Physics IV, KTH, Stockholm, has been conceived with the intent of allowing interaction between three parties: an operator, a measuring machine and a computer.

Seen from the computer the photographic plate in IRIS is a read-only memory, similar to other mass storages. As such it has the additional advantage (e.g. compared with magnetic tape) of allowing simultaneous, random access in two dimensions. At the same time it is also available for visual observations, by means of optical and electronic displays.

To provide for this twofold role of the plate IRIS is equipped with two different scanning systems. A small, rectangular region around the measuring point is covered by means of fast scanning, with a repetition frequency fitted to the speed of human apperception. In addition scanning can be performed by moving the tables, as is common in most measuring machines.

The fast scanning allows for visual displays on CRT screens of the intensity profiles along two perpendicular directions through the central measuring point. Moreover it supplies the measuring machine with the information necessary to perform automatic settings on objects on the plate, e.g. on stars. Further, it makes it possible for the computer to calculate the gradient of the density distribution, e.g. in order to track equidensity curves. It also offers the capability of fast raster scanning.

To make certain a high photometric accuracy IRIS has a calibration system which relates all measurements to a scale defined by two

separate reference levels. This calibration is synchronized with the fast scanning and it compensates for changes in illumination, slit width, PM-tube and amplifier gain.

Accounts are given on the application of IRIS to different measuring tasks.

## INTRODUCTION

An early example of the use of two different scanning systems in a measuring machine is given by the so called Spiral Reader. This machine was originally built by prof. L. Alvarez at Berkeley to measure bubble chamber plates. Here a fast rotating system provides for an efficient use of the measuring time by allowing a desired concentration on the objects of interest. The movement from one such object to another is accomplished by moving the measuring tables.

The same basic philosophy has been adopted in IRIS. However, IRIS is a general purpose machine, that can be used to measure any kind of patterns recorded on photographic plates. Hence the fast scanning has been designed to supply very basic information about the density distribution around the measuring point, e.g. the size and direction of the density gradient. Like the Spiral Reader this new machine has been designed to work with a computer. Further, the idea of making use of interactive procedures has been extended and has led to a design, that allows efficient communication between three parties: the operator, the measuring machine and the computer.

These objectives sometimes necessitate an unorthodox design, since they may lead to conflicting demands. As an example we may take the problem of illuminating the plate. To display the plate to the operator, a large part of it has to be illuminated. On the other hand the photometric-readings communicated to the computer should not be distorted due to straylight. This raises a demand for a very small illuminated area. The method chosen in IRIS is to use light of different spectral composition for the different purposes.

Another example comes from the demand that the operator and the machine be close to each other, physically, which is in conflict with the demand that mechanical or thermal disturbances should be avoided.

In addition there have also been some more general principles employed in the design work:

1) To acquire the high accuracy (both in positioning and photometry) rather by automatic calibrations than by large-scale

use of high precision components.

2) To make use of the on-line computer as a tool in the process of refining the design.

The design of the machine reflects the cooperative effort of a research group and an industry. Thus a basic idea has been to create a multi-purpose platform that can be suited to different measuring tasks by modular expansions. This platform comprises both hardware and software.

The present exposition serves to exemplify how these different objectives and principles materialize in the machine and in the use of it.

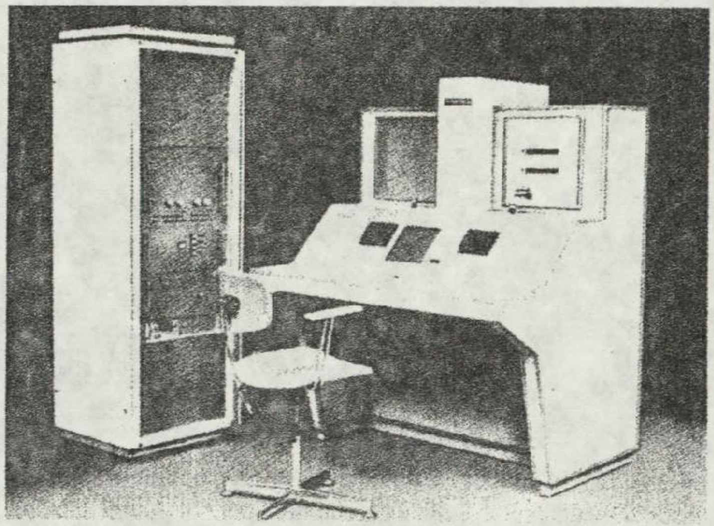


Fig.1. The operator controls the measurements from a console that includes both optical and electronic displays. The plate is mounted into the machine from behind. The outer cover is mechanically isolated from the inner parts of the machine.

THE TWO SCANNING SYSTEMS

The measuring tables, which constitute the slow scanning system, are vertical to avoid bending of the plate due to gravitation. Actual positions of the tables are measured by separate linear digital encoders.

images pass either of the two fast scanning devices, which effectuate X- and Y-scanning respectively.

Refocussing can be performed during the course of the measurements, by moving the detector assemblies. An unintentional, sidewise displacement of the slit when doing this will introduce no parallaxes, since it will not change the position of the plate image in relation to the image of the index mark. Further the imaging is telecentric so that the magnification will not be affected by this refocusing.

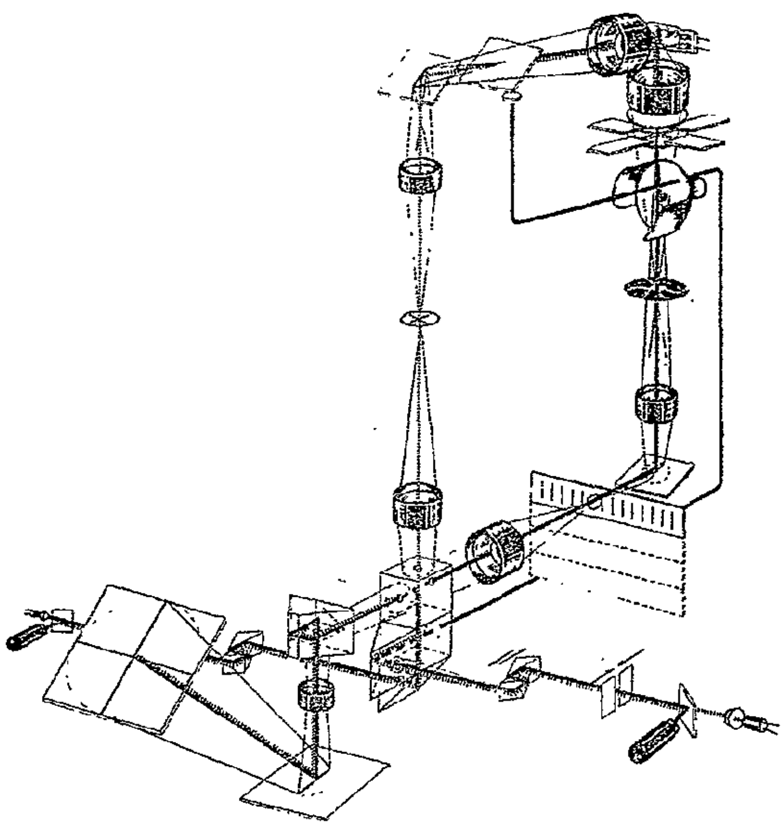


Fig.3. Reference channels for positioning (in the front) and for intensity (fiber optics) allow continous comparisons with fixed references. The plate is indicated in the figure but not the measuring tables.

An example of the expansion capability of the design is provided by the index mark. It can be replaced by a grid of black squares, which define length scales for the fast scanning motions in the X- and Y directions. This makes possible very fast raster scanning with a fixed step length. The first grid produced for this purpose has a step length of 25 micrometers.

The second reference channel is for intensity. Once every cycle of the fast scanning the illumination of the plate is turned off by means of a chopper which is synchronized with the movement of the vibrating prisms. This defines a reference level for darkness. Further, while the illumination of the plate is off, a light pulse that bypasses the plate is supplied to the detectors. The magnitude of the resulting electronic pulse relative to the darkness level is compared with a fixed reference voltage. The electronic amplification is regulated to keep this magnitude constant. In this way drifts, not only in the lamp but also in the PM tube and in the amplifier are compensated for. Consequently the PM tube may be driven with a higher current than normally, since slow changes of this tube are of no consequences. This benefits the dynamic range of the photometric measurements (presently the dynamic range is just below 4 decades).

Since the slit is also included in the chain of elements that is encompassed by this regulation, the slit width may be changed without changing the intensity scale. The optimal slit width can thus be set very conveniently by operator interaction, since a change of the slit will only change the form and not the size of the profile on the CRT screen.

## PROCEDURES TO TEST AND TO REFINE THE MACHINE

Interactive procedures have been established to verify and refine the merits of the machine as a densitometer and as a comparator. To test the photometric qualities the operator decides what objects shall be investigated, e.g. the fields of a gray scale, and directs the machine manually to these objects. The position coordinates are stored, together with the photometric data from the X and Y detectors. These latter values are obtained by integrating the transmitted light over rectangular measuring windows. The one side of such a rectangle is determined by how long a part of each cycle of the fast scanning the detected signal is integrated. (The actual setting is indicated on the CRT screen by a strengthening of the profile along that portion). The other side is determined by the width of a preslit.

The computer will take over and repeat the measurements an arbitrary number of times. This gives a good opportunity for studying the effects of different changes of machine parameters on these measurements.

This is also done when testing the machine as a comparator. A precision grid plate is measured, and the machine makes automatic settings on the crossing points of this grid. This is possible since the machine has the ability of setting on the median in the X- and Y- direction of any intensity distribution on the plate, Åslund (1965). The (rectangular) areas of integration employed at these settings can be choosen at will. In the present application the median setting is used both to make the machine follow the mesh lines and to make it perform repeated settings on the crossing points.

During these measurements, which allow a separation of the random and the systematic errors, the computer also collects data from different sensors placed at arbitrary points of the machine, measuring voltages or temperatures. A data analysis is performed to reveal any correlation between the systematic errors observed at the measurements on the grid and the changes of these parameters. In this way it has been possible to trace the main error sources in the machine and to take appropriate counter measures. Presently the environment of the machine is not temperature controlled but at night test, with temperature changes within ± 0.5 °C, the machine has remained stable for several hours within ± 0.5 micrometers.

## APPLICATIONS OF THE MACHINE

One major application project concerns the measuring and evaluation of optical spectra. An interactive procedure is employed, where the operator decides whether to employ the median setting procedure or to scan the line. The latter can be done step by step or by continuous sweeping. From the identified reference lines the computer calculates a coarse calibration curve, which can be improved by including more reference lines. Further, from this calibration curve the wavelength (or wave number) of a line under investigation can be displayed immediately, on a data screen. A main feature of the procedure is that every determination can be supplied with a standard deviation, to accompany it during the subsequent calculations.

Another application concerns the measuring of spectral reflectances of trees on aerial photographs of forests. The individual trees are approximated by polygons, defined manually by the operator. The computer refinds the same tree on other plates, representing recordings in other spectral regions, e.g. to determine the relative frequencies of different density values within these polygons. The results are presented as histograms on a data screen, and the aim of the study is to find out what makes it possible for a human interpreter to identify different types of trees on anaerial photograph. The method employed is representative for a basic idea of this machine, to make possible conversations between operator, computer and machine.

## REFERENCES

Åslund, N: 1965, Dissert., Dept. of Physics, University of Stockholm.

APPENDIX C

FOA rapport
D 30055-E1
Oktober 1976

# Program library for handling and processing of remotely sensed multispectral data

Lars Erik Gustafsson and S Ingvar Åkersten

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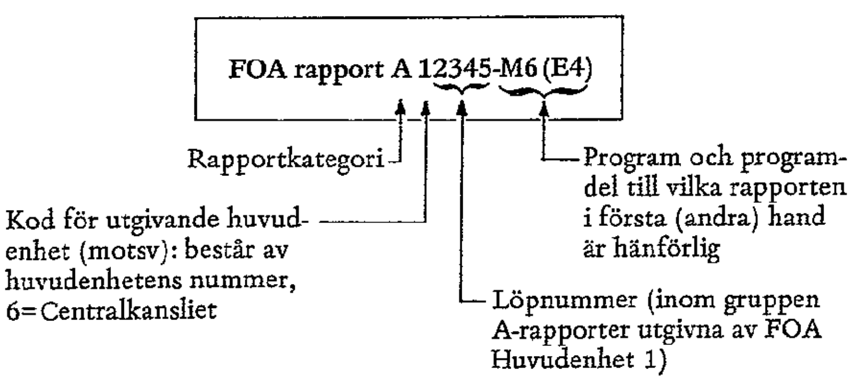
FOA-rapports status är att författaren (författarna) svarar för rapportens innehåll, t ex för att angivna resultat är riktiga, för gjorda slutsatser och rekommendationer etc.

FOA svarar – genom att rapporten godkänts för utgivning som FOA-rapport – för att det redovisade arbetet utförts i överensstämmelse med »vetenskap och praxis» på ifrågavarande område.

I förekommande fall tar FOA ställning till i rapporten gjorda bedömningar etc; detta anges i så fall i särskild ordning, t ex i missiv.

## REGISTRERING

Fr o m 1974-07-01 registreras FOA-rapport enligt följande exempel:




FOA REPRO
Stockholm 1975

Försvarets forskningsanstalt
Huvudavdelning 3
104 50 Stockholm

FOA rapport
D 30055-E1
Oktober 1976

# PROGRAM LIBRARY FOR HANDLING AND PROCESSING OF REMOTELY SENSED MULTISPECTRAL DATA

Lars Erik Gustafsson and S Ingvar Åkersten

## Abstract

A brief user's guide to a system of computer programs for the handling, processing and analysis of multispectral pictorial data is presented. The system is being developed at FOA and is implemented on an IBM 360/75 at the Stockholm computer center. Currently the programs are used in pure batch processing with one specially prepared source deck for every separate application task. Examples are given of typical combinations of tasks for image generation and object identification starting with appropriately edited digital data.

Uppdragsnummer: ER 30B

Sändlista: Fst, FMV, FMV-A, FMV-M, FMV-F, FMV-BNL, MHS, FOA Ck, Havd 1, Havd 2, Havd 4, Havd 5
Havd 3: 300, 355, 314

Försvarets forskningsanstalt
Huvudavdelning 3
104 50 Stockholm

FOA rapport
D 30055-E1
Oktober 1976

# PROGRAMBIBLIOTEK FÖR HANTERING OCH BEARBETNING AV MULTISPEKTRALA DATA

Lars Erik Gustafsson och S Ingvar Åkersten

## Sammanfattning

En kortfattad användar-handledning av ett datorprogramsystem för hantering, bearbetning och analys av multispektrala bilddata presenteras. Systemet är under utveckling vid FOA och är implementerat på en IBM 360/75 vid Stockholms datacentral. För närvarande används programmen i ren batch-bearbetning med en speciellt iordninggjord hålkortbunt för varje tillämpningsuppgift. Exempel ges på typiska kombinationer av arbetssteg för bildgenerering och objektidentifiering med utgångspunkt från systemredigerade digitala data.

Uppdragsnummer: ER 30B

Sändlista: Fst, FMV, FMV-A, FMV-M, FMV-F, FMV-BNL, MHS, FOA Ck, Havd 1, Havd 2, Havd 4, Havd 5
Havd 3: 300, 355, 314

CONTENT

Manuskriptet mottaget 1976-09-23/AH

## INTRODUCTION

Technological advances during recent years have lead to a need for research and development of methods in the new field of computer aided analysis of pictorial information. An obvious example of such a need for unconventional image processing/photo interpretation techniques is the optimal reconstruction of imagery recorded by interplanetary space-probes and transmitted in telephoto-like fashion to earth. Another example is the attempt to extract earth resources and environmental management information from similar data collected with scanning photometers over a large area and digitized in such a manner that each ground areal element is recorded in several discrete wavelength bands of the electromagnetic spectrum. This report constitutes a brief user's guide of a system of computer programs being developed at the Image Processing Section (355) of the Swedish National Defence Research Institute (FOA) for the handling, processing and analysis of such multispectral pictorial data and implemented on the IBM 360/75 at the Stockholm Computer Center. The fact that the methods are still being developed implies of course that each program description is only an account of the current status of the system rather than a final documentation product.

A guiding philosophy - so far - has been to work solely in an extreme form of batch processing, viz. using one specially prepared deck of punched cards, a so called source deck, for each separate processing task. Naturally the bulk of the system subroutines are stored on an internal computer memory to simplify the source deck handling and to minimize the program initiation and running times. Occasionally one has to use a subroutine in punched card version - especially for infrequently recurring tasks, recently completed subroutines or adhoc subroutines being developed to deal with some specific application task problem not already covered by the system.

One specific feature - unavoidable for the huge volume, multi-spectral pictorial data considered here - is the use of an internal label for every image being processed. It is a must for program administration, for simplified data handling and for data-type-dependent documentation purposes. Currently satellite (LANDSAT (4 channels), NOAA/VHRR (2 channels)) and aircraft (Swedish MSS-75 campaign (10 channels)) data are available at FOA 355 for processing.

The presentation of the program system has been formed as a description of the specific source deck used for each separate task and with the tasks grouped according to their purpose e.g. data editing, image generation and so on. In general every separate task source deck description follows a standard layout:

- short description of what the program does
- computer listing of the appropriate BLOCK DATA
- discussion of those variables in BLOCK DATA which may/must be altered
- specification of which subroutines are used
- line printer documentation log sheet for the actual run exemplified by the BLOCK DATA.

Note that the second and last points refer to actual computer listings being inserted in the running text and that all discussions of these points are limited to the specific task which they exemplify.

DESCRIPTION OF SOURCE DECK

A typical source deck (figure 2) consists of punched cards with the following general structure.

Job control cards (at several positions in the deck)

SUBROUTINE CALLS

BLOCK DATA

Dataset card(s)

Comment card(s) (to be printed on line printer)

The overall program structure is the same in all tasks. A subroutine PILOT calls three different subroutines; TODAYS, LEGEND and CALLS (figure 1). TODAYS prints on line printer the date and LEGEND the text of the user comment cards at the end of the deck of cards. CALLS is used to define one specific subroutine for every task.

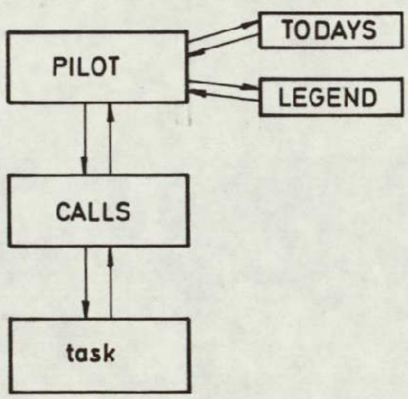



Figure 1. The overall program structure.

In most of the tasks a subroutine called TGHEAD prints the input dataset identification head as part of the task documentation on line printer.

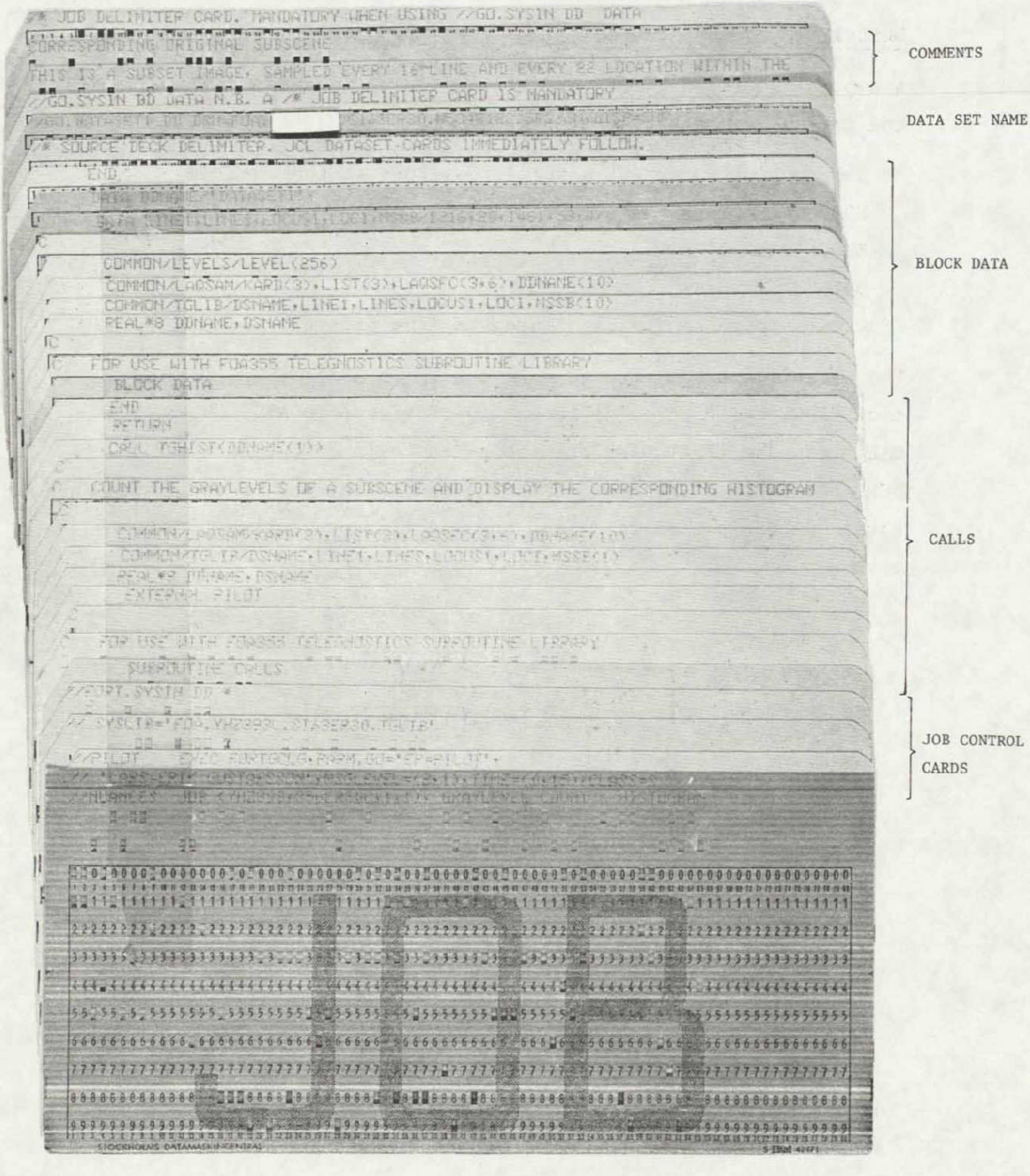



Figure 2. The deck of the cards for a typical task.

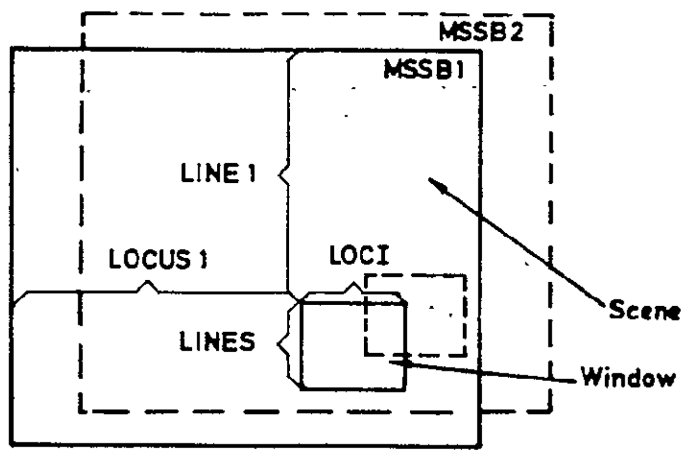



Figure 4. To specify a window.

DESCRIPTION OF TASKS

DATA EDITING

CCTMERGE

Merges and reedits the data from a set of four NASA C(omputer) C(ompatible) T(ape)s (figure 5) onto a single tape called MERGED (figure 6). An interim earth rotation rectification is performed. Also a 256 bytes label will be produced on the single tape.

```
      BLOCK DATA
C     FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      COMMON/INCCT/INCCT(4)
      REAL*8 DDNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
C
      DATA INCCT/0,2,3,4/
      DATA DDNAME/'CCT14    ','CCT24    ','CCT34    ','CCT44    ',
     2'MRGFILE1','MRGFILE2','MRGFILE3','MRGFILE4','MRGFILE5'/
      END
```

| | |
|---|---|
| DATA INCCT/0,2,3,4/ | INCCT(1)=0 CCT 1/4 is not available for merging. |
| | INCCT(2)=2 CCT 2/4 exists etc. |

Subroutines in this task:

MERGE(MODIFY,IATICK,INTBYT,BYTINT)

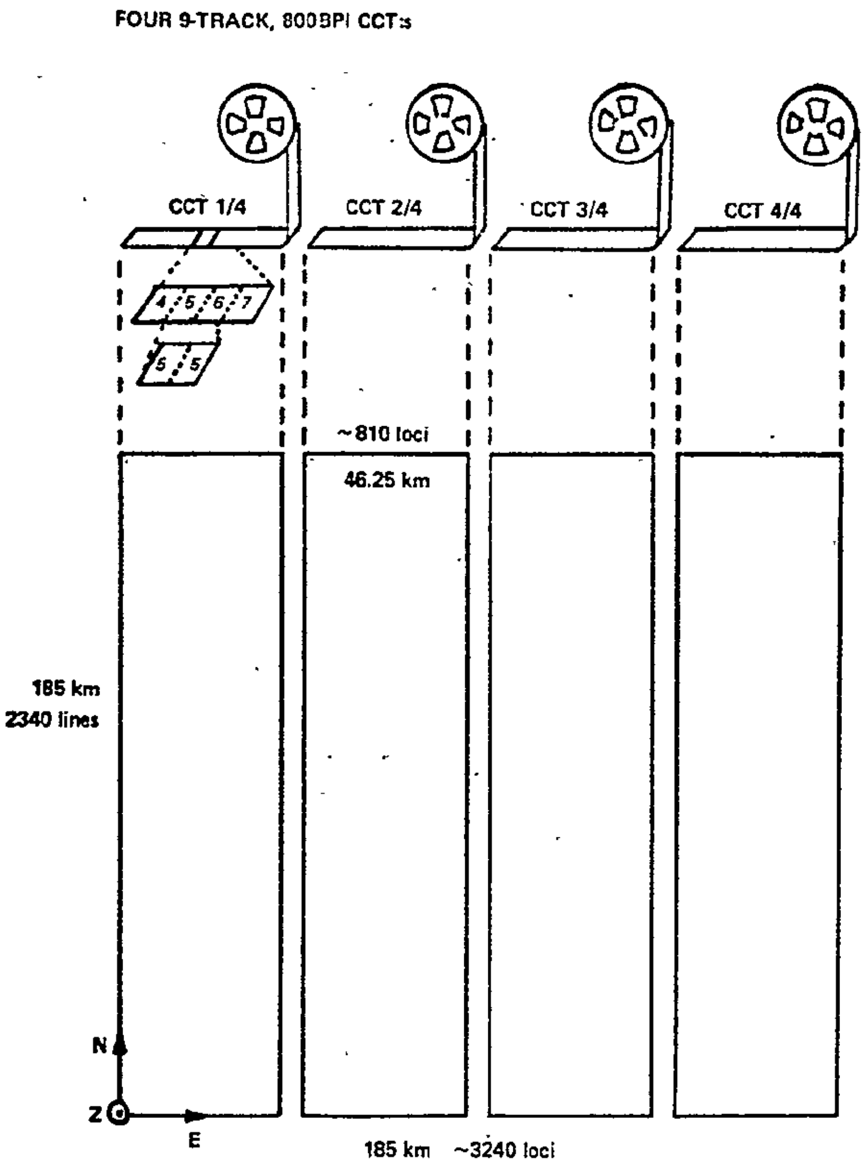



Figure 5. Original NASA LANDSAT CCT format.

ORIGINAL PAGE IS
OF POOR QUALITY

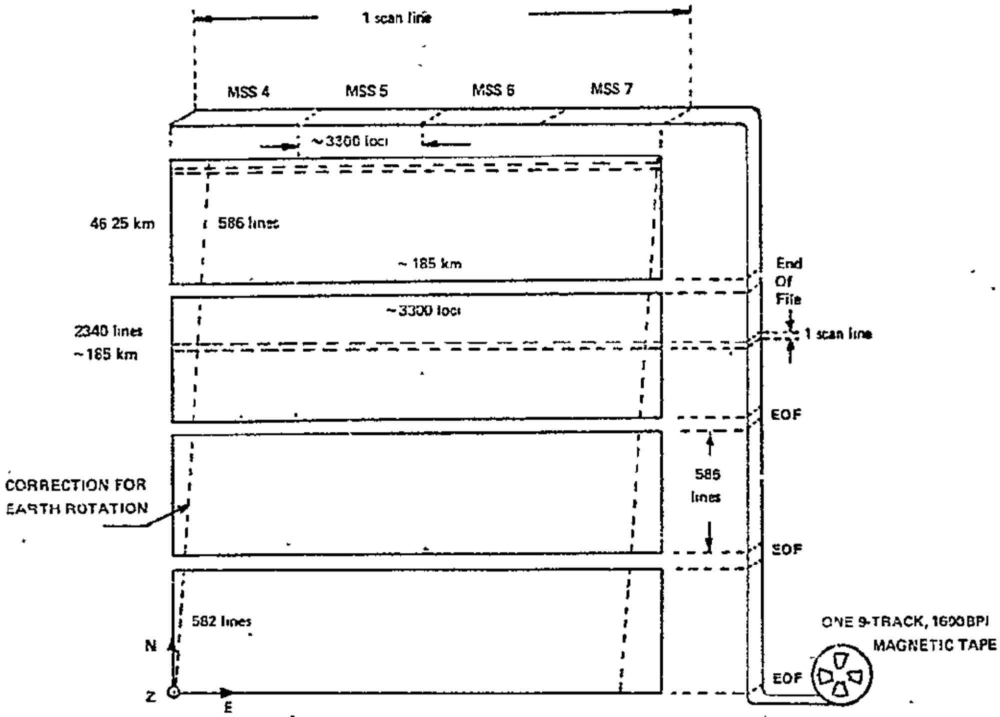



Figure 6. FOA 355 merged and earth rotation corrected LANDSAT CCT format.

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-14)

CCT-MERGING, INTERIM EARTH ROTATION RECTIFICATION AND LINE-INTERLEAVING OF THE
FOUR LANDSAT MSS-BANDS ON A 9-TRACK 1600 BPI MAGNETIC TAPE LABELLED: MERGED 1039-09381



```
SCENE/FRAME ID  CCT SEQ.  DATA RECORD     BINARY FRAME ID            BINARY      IAT ID    MSS DATA MODE/    MSS ADJUSTED ACTUAL MERGED
 SDDD-HHMMSBN    NUMBER     LENGTH    SAT.CODE DDD HH MM TS         STRIP ID              CORRECTION CODE  LINE LENGTH  RECORDLENGTH
 1039-0938100     2 4        3296          1  39  9 38  1  0  0         0      SI182111     0  00100111        3240           13640

EXPOSURE  SCENE CENTER    SATELLITE NADIR                      SOLAR POSITION SAT|REV.    DEFIN.                          MSS DATA ACQUISITION
DATE; UT   LAT   LONG        LAT   LONG                         ELEV.   AZIM. DIR|NUMB.    PRED.                            DIRECT|ALASKA
                                                                              DEG|         ORBIT                              OR  |GOLDSTONE
                                                                                                                           RECORD|NASAGSFC
31AUG72 C N47-21/E011-00 N N47-20/E011-05                      SUN EL45 AZ143 193-0539- -1-  D-   NASA ERTS E-1039-09381-     R N-

 1039-0938100     3 4        3296          1  39  9 38  1  0  0         0      SI182111     0  00100111        3240           13640
31AUG72 C N47-21/E011-00 N N47-20/E011-05                      SUN EL45 AZ143 193-0539- -1-  D-   NASA ERTS E-1039-09381-     R N-

 1039-0938100     4 4        3296          1  39  9 38  1  0  0         0      SI182111     0  00100111        3240           13640
31AUG72 C N47-21/E011-00 N N47-20/E011-05                      SUN EL45 AZ143 193-0539- -1-  D-   NASA ERTS E-1039-09381-     R N-

TICK MARK POSITIONS ALONG THE NASA PRODUCED IMAGERY EDGES (SIGNED INTEGER FRACTIONS)
TOP EDGE          3705  E011-00|    -9814  E012-00|   -14126  N048-00|       0  ########        0  ########      0  ########
LEFT EDGE        -9446  N048-00=      964  N047-30=    11371  N047-00=       0  ########        0  ########      0  ########
RIGHT EDGE      -11970  =E012-30    -7609  =N047-30     2901  N047-00=   13402  N046-30=        0  ########      0  ########
BOTTOM EDGE       9962  E010-00|     3040  E010-30|    -2606  N046-30|   -3908  |E011-00   -10882  |E011-30      0  ########
```

SIX GROUND POINTS AT EACH END OF EVERY SCANLINE ARE NOT RECORDED IN ALL FOUR WAVELENGTH BANDS. AFTER THE CORIOLIS-EFFECT ADJUSTMENT THE ACTUAL GROUND AREA IMAGED IN ALL FOUR WAVELENGTH BANDS IS HERE CONTAINED WITHIN:

```
    (    1, 163)          (    1,3390)   TOTAL (LEFT+RIGHT) NUMBER OF EQUIVALENT GROUND POINT LOCATIONS IN THE RECTIFYING MARGIN =156
    |       /--------------------/ |
    |      /--------------------/  |
    |     /--------------------/   |
    |    /--------------------/    |
    |   /--------------------/     |
 (2340,    7)           (2340,3234)       APPROXIMATE NUMBER OF LINES WITHOUT MARGIN ADJUSTMENT = 15
```

THE PADDING PIXELS REQUIRED FOR THE GEOMETRIC RECTIFICATION ALL HAVE THE HEXADECIMAL VALUE FF. (I.E. DECIMAL 255)
IN MRGFILE2 THE FIRST LINE IS     1 AND THE LAST  586
IN MRGFILE3 THE FIRST LINE IS   587 AND THE LAST 1172
IN MRGFILE4 THE FIRST LINE IS  1173 AND THE LAST 1758
IN MRGFILE5 THE FIRST LINE IS  1759 AND THE LAST 2340

```
MERGED SUBSCENE:     LINE1     LINES    LOCUS1      LOCI      OF MSSBANDS
      N472E110          1       2340        1       3396        ALL FOUR
```

FOR ALL SUBSCENE TAPPINGS FROM THE MERGED TAPE ONE MUST SPECIFY THE ABSOLUTE COORDINATES (BEGINNING AT 1) OF THE LOCATION OF THE FIRST GROUND POINT ON THE FIRST LINE TO BE TRANSFERRED, THE RANGES FOR LINES AND PIXEL LOCATIONS ALONG THOSE LINES, AS WELL AS THE WAVELENGTH NUMBERS COMPLETING THE IDENTIFICATION OF THE SELECTED SUBSCENE

SUMMER-SCHOOL ALPBACH 1976
PRACTICAL APPLICATION OF REMOTE SENSING
WORKSHOP 4A: DIGITAL PROCESSING TECHNIQUES
ORHAUG/FOA355 1976

DATE 76-07-14

REPLIC8

To solve the problem with only two NASA CCTs, each one containing two or the four original NASA CCTs. Replicating one of the two original NASA CCTs contained on each one of the 'two-set' tapes.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
C
      DATA DDNAME/'ORIGINAL','REPLICA '/
      END
```

Nothing to change in BLOCK DATA.

Subroutines in this task:

Only CALLS.

684-REPLICA PAGE 8

SCENE IDENTIFICATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE

| SCENE/FRAME ID | CCT SEQ. | DATA RECORD | IAT ID | BINARY DATA MODE/ | MSS ADJUSTED |
|---|---|---|---|---|---|
| SDDD-HHMMSSN | NUMBER | LENGTH | | CORRECTION CODE | LINE LENGTH |
| 1039-0938100 | 2 4 | 3296 | SI182111 | 39 | 3240 |

2342 RECORDS HAVE BEEN REPLICATED

REPLICATING CCT24 FROM A LANDSAT-COPY-TAPE

DATE 76-06-09

SIXPACK

Converts 7-track NASA LANDSAT tape to 9-track tape.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      DATA DDNAME/'SOURCE  ','SINK    '/
      END
```

Nothing to change in BLOCK DATA.

Subroutines in this task:

SIXPACK(WEGZWO)

107-SIXPACK PAGE. .16

SCENE/FRAME IDENTIFICATION LOG FOR FOA355 LANDSAT MSS BULK CCT ARCHIVE

CONVERTING 7-TRACK LANDSAT CCT TO 9-TRACK

| SCENE/FRAME ID SDDD-HHMMSBN | CCT SEQ. NUMBER | DATA RECORD LENGTH | IAT ID | BINARY DATA MODE/ CORRECTION CODE | MSS ADJUSTED LINE LENGTH |
|---|---|---|---|---|---|
| 1039-0931500 | 1 4 | 3296 | SI509701 | 39 | 3240 |

| EXPOSURE DATE; UT | SCENE CENTER LAT LONG | SATELLITE NADIR LAT LONG | SOLAR POSITION ELEV. AZIM. | SAT\|REV. DIR\|NUMB. DEG\| | DEFIN. PRED. ORBIT | | MSS DATA ACQUISITION DIRECT\|ALASKA OR \|GOLDSTONE RECORD\|NASAGSFC |
|---|---|---|---|---|---|---|---|
| 31AUG72 | C N68-05/E025-54 | N N68-03/E026-00 | SUN EL30 AZ167 | 204-0539- -1- | D- | NASA ERTS E-1039-09315- | R N- |

2342 RECORDS HAVE BEEN TRANSFERRED

VK14 (7-TRACK) -> CCT14 (9-TRACK) CONVERSION; 1039-09315 NORTHERN FINLAND
VILJO KOUSMANEN

DATE 76-05-19

WINDOW EXTRACTION

MERGTAP

Transfers the 256 bytes label, reedited, and the selected channels of a LANDSAT window from an edited 1600 BPI tape to disk or tape.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,5),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/PLOTTG/LINER8,LISTEP,LOSTEP,DASH
C
      DATA DSNAME/'STARNBRG'/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/ 239, 512,1689, 512,4,5,7/
      DATA LISTEP,LOSTEP/ 1, 1/
      DATA DDNAME/'MRGFILE1','MRGFILE2','MRGFILE3','MRGFILE4','MRGFILE5'
     2,'DATASET0'/
      END
```

| | |
|---|---|
| DATA DSNAME/'STARNBRG'/ | Name of the window transferred. Is given by the user. |
| DATA LINE1,... | See the description of the source deck. |
| DATA LISTEP,LOSTEP/1,1/ | LISTEP=1 and LOSTEP=1 means that every line and every pixel along that line (within the selected window) is transferred. |

Subroutines in this task:
MRGTAP(BYTINT,INTBYT)

123-MERGTAP PAGE 14

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-15)

LANDSAT:

TRANSFERRAL OF 1039-09381 MSSYCI SUBSCENE FROM MERGED 1600 BPI MAGNETIC TAPE

EXTRACTION OF SELECTED MSSBANDS

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | CCTS MERGED | MSS DATA MODE/ CORRECTION CODE | ACTUAL MERGED RECORDLENGTH |
|---|---|---|---|---|---|
| 1039-0938100 | 31AUG72 C | N47-21/E011-00 | 0 2 3 4 | 00100111 | 13640 |

| INPUT DATASET SUBSCENE: | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| N472E110 | 1 | 2340 | 1 | 3396 | 4 5 6 7 |
| SELECTED SUBSCENE: | 239 | 512 | 1689 | 512 | SAMPLED EVERY 1 LINE AND EVERY 1 LOCATION, THUS YIELDING THE |
| OUTPUT SUBIMAGE: STARNBRG | 239 | 512 | 1689 | 512 | 4 5 0 7 |

STARNBERGER SEE AND SURROUNDINGS

SUMMER-SCHOOL ALPBACH 1976
PRACTICAL APPLICATION OF REMOTE SENSING
WORKSHOP 4A: DIGITAL PROCESSING TECHNIQUES
ORHAUG/FOA355 1976

DATE 76-07-15

CCTAP

Transfers selected channels of a LANDSAT window from a tape with data in original NASA CCT format. An interim earth rotation rectification and a 256 bytes label will be produced.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCCT1,LOC1,MSSB(10)
C
      DATA LINE1,LINES,LOCCT1,LOC1,MSSB/ 306, 256, 555, 256,4,5,6,7/
      DATA DDNAME/'DATASETI','DATASETO'/
      END
```

DATA LINE1,... See the description of the source deck.

Subroutines in this task:
CCTAP(INTBYT,BYTINT,MODIFY,IATICK)

```
929-CCTAP     PAGE     14

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-13)

LANDSAT:

SCENE/FRAME ID  CCT SEQ.  DATA RECORD      BINARY FRAME ID           BINARY     IAT ID    MSS DATA MODE/    MSS ADJUSTED CORIOLISRECT
 SDDD-HHMMSBN    NUMBER    LENGTH     SAT.CODE DDD HH MM TS          STRIP ID             CORRECTION CODE   LINE LENGTH   LINE LENGTH
 1039-0938100     2 4       3296            1  39  9 38  1  0  0      0       SI182111    D, 00100111        3240          3396

EXPOSURE  SCENE CENTER    SATELLITE NADIR                    SOLAR POSITION SAT|REV.     DEFIN.                     MSS DATA ACQUISITION
DATE; UT   LAT   LONG        LAT    LONG                      ELEV.   AZIM. DIR|NUMB.    PRED.                        DIRECT|ALASKA
                                                                           DEG|         ORBIT                          OR   |GOLDSTONE
                                                                                                                    RECORD|NASAGSFC
31AUG72 C N47-21/E011-00 N N47-20/E011-05                   SUN EL45 AZ143 193-0539- -1-  D-    NASA ERTS E-1039-09381-     R N-

TICK MARK POSITIONS ALONG THE NASA PRODUCED IMAGERY EDGES (SIGNED INTEGER FRACTIONS)
TOP EDGE        3705  E011-00|    -9814  E012-00|   -14126  N048-00|       0  ########        0  ########        0  ########
LEFT EDGE      -9446  N048-00=      964  N047-30=    11371  N047-00=       0  ########        0  ########        0  ########
RIGHT EDGE    -11970  =E012-30    -7609  =N047-30     2901  N047-00=   13402  N046-30=        0  ########        0  ########
BOTTOM EDGE     9962  E010-00|     3040  E010-30|    -2606  N046-30|   -3908  |E011-00   -10882  |E011-30        0  ########


SELECTED SUBSCENE:          LINE1     LINES     LOCUS1      LOC1      OF MSSBANDS
    N472E110                 306       256       1365        256        4  5  6  7

SUMMER-SCHOOL ALPBACH 1976
PRACTICAL APPLICATION OF REMOTE SENSING
WORKSHOP 4A: DIGITAL PROCESSING TECHNIQUES
ORHAUG/FOA355 1976

DATE 76-07-13
```

CNESTAP

A window is transferred from a CNES75-tape to disk or tape. Also a 256 bytes label will be produced.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOC1,MSSB(10)
C
      DATA DSNAME/'LÅRSTAVK'/
      DATA LINE1,LINES,LOCUS1,LCC1,MSSB/875,600,381,132,4,5,10/
      DATA DDNAME/'CNESTAPE','CNESCENE','DATASETO'/
      END
```

DATA DSNAME/'LÅRSTVKN'/ — Name of the window transferred to disk or tape. Optional 8 alfanumerical characters given by the user.

DATA LINE1,... — See the descirption of the source deck.

Subroutines in this task:
BYTINT,INTBYT

C.2





SCENE IDENTIFICATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE

| SCENE IDENTIFICATION | REG. DATE | UT HH | MM | SS | MS |
|---|---|---|---|---|---|
| SU75030A LARSTAVIKEN | 04/07/75 | 12 | 7 | 34 | 158 |

TRANSFERRAL OF A SUBSCENE TO DISK DATASET

DATE 76-06-17

WINDOW EXAMINATION

NUANCES

NUANCES counts the graylevels of a window and displays the corresponding histogram(s).

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/LEVELS/LEVEL(256)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1216,20,1461,53,4/
      DATA DDNAME/'DATASETI'/
      END
```

DATA LINE1,...      See the description of the source deck.

Subroutines in this task:

TGHIST(GRALEV(TGHEAD,INTBYT))

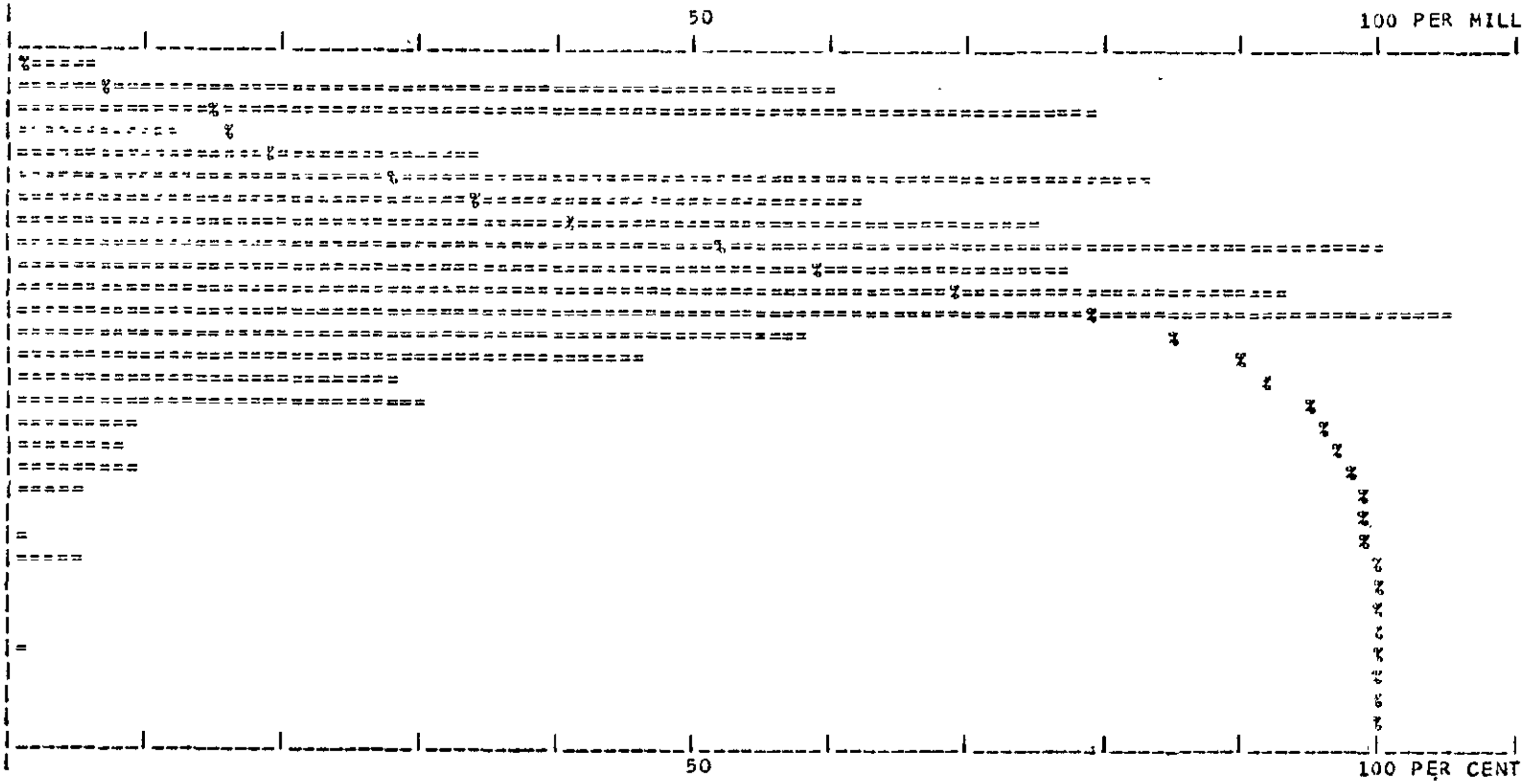
TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-06)

LANDSAT:

| SCENE/FRAME ID SODD-HHMMSON | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-0952300 | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 12968 |

| | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS 4 5 6 7 |
|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: N584E122 | 1201 | 128 | 1387 | 128 | 4 5 6 7 |
| LEVELCOUNTED SUBSCENE: | 1216 | 20 | 1461 | 53 | 4 0 0 0 |

| ACCUMUL. COUNT | PIXEL COUNT | GRAY LEVEL |
|---|---|---|
| 7 | 7 | 16 |
| 71 | 64 | 17 |
| 155 | 84 | 18 |
| 168 | 13 | 19 |
| 205 | 37 | 20 |
| 293 | 88 | 21 |
| 359 | 66 | 22 |
| 439 | 80 | 23 |
| 546 | 107 | 24 |
| 628 | 82 | 25 |
| 727 | 99 | 26 |
| 839 | 112 | 27 |
| 901 | 62 | 28 |
| 950 | 49 | 29 |
| 980 | 30 | 30 |
| 1012 | 32 | 31 |
| 1022 | 10 | 32 |
| 1031 | 9 | 33 |
| 1041 | 10 | 34 |
| 1047 | 6 | 35 |
| 1047 | 0 | 36 |
| 1049 | 2 | 37 |
| 1055 | 6 | 38 |
| 1055 | 0 | 39 |
| 1056 | 1 | 40 |
| 1056 | 0 | 41 |
| 1058 | 2 | 42 |
| 1059 | 1 | 43 |
| 1059 | 0 | 44 |
| 1060 | 1 | 45 |




RELATIVE PIXEL COUNT

DATE 76-09-06

ORIGINAL PAGE IS OF POOR QUALITY

HISTOGR

The program selectively counts pixel graylevels within a chosen window and displays a histogram. In one of the channels an interval is specified by the user. For pixels in this channel with graylevels within the interval a histogram is computed. For the corresponding pixels in other channels histograms may also be displayed. Another option is to give a matrix consisting of zeroes and ones. The matrix gives a mask of ones marking the pixels to be included in the frequency count.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      INTEGER*2 MASK,SELECT
      INTEGER*2 THRSH1,THRSH2,MSCNR
      REAL*8 DDNAME,DSNAME
      COMMON/THRSH/THRSH1,THRSH2,MSCNR
      COMMON/VEK/SELECT,MASK(2500)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/LEVELS/LEVEL(256)
C
C    SELECT=0 (FOR USING THRESHOLDS)
C    SELECT=1 (FOR USING 'MASK')
C    IN BAND MSCNR IS PIXELS COUNTING BETWEEN ONLY GRAYLEVELS THRSH1 AND THRSH2
C
C
      DATA SELECT/0/
      DATA MASK/1,0,2*1,0,4*1,0,4*1,0,4*1,0,4*1,0,1,1,0,1,1/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/754,14,2639,12,4,5,7/
      DATA THRSH1,THRSH2,MSCNR/13,18,5/
C
C    IN MSSB(1),... ARE THE SAME PIXELS COUNTING AS THEY IN BAND MSCNR
C
      DATA DDNAME/'DATASET1'/
      END
```

| | |
|---|---|
| COMMON/VEK/SELECT,MASK(x) | x must not be smaller than LOCI*LINES. |
| DATA SELECT/0/ | SELECT=0 For thresholds. |
| | SELECT=1 For mask (punched matrix of zeroes and ones). |
| DATA MASK/1,0,2*1,...,1,1/ | If SELECT=1, punch 1 if the pixel shall be counted otherwise 0. |

A matrix

```
1 0 1 1 0
1 1 1 1 0
1 1 1 1 0
1 1 1 1 0
1 1 1 1 0
1 1 0 1 1
```

will require MASK of the form indicated.

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA THRSH1,THRSH2,MSCNR/13,18,5/ | THRSH1=13 The lower threshold.<br>THRSH2=18 The higher threshold.<br>MSCNR=5 Number of the threshold channel. |

Subroutines in this task:
HISTO2(HISTO1(TGHEAD,INTBYT))

951-HISTOGR PAGE 8

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-15)

LANDSAT:

```
SCENE/FRAME ID   EXPOSURE   SCENE CENTER      ORIGINAL  CORIOLISRECTIFIED
 SDDD-HHMMSBN    DATE; UT    LAT    LONG       CCT(S):      LINE LENGTH
 1043-0957400    04SEP72 C  N58-33/E011-14    0 2 3 4          3358

INPUT DATASET SUBSCENE:        LINE1     LINES    LOCUS1     LOCI     OF MSSBANDS
       KROPPEFJ                  607       256      2432      256      4  5  6  7
LEVELCOUNTED SUBSCENE:           754        14      2639       12      0  5  0  0

 ACCUMUL. PIXEL GRAY |                                         50                                        100 PER MILL
  COUNT   COUNT LEVEL|_________|_________|_________|_________|_________|_________|_________|_________|_________|_________|
     8       8    13 |=====X==========================================================================
    33      25    14 |-----------------------------X---------------------------------------------------------------- 227 PER MILL
    60      27    15 |-------------------------------------------------------X-------------------------------------- 245 PER MILL
    85      25    16 |-----------------------------------------------------------------------------X---------------- 227 PER MILL
   106      21    17 |-----------------------------------------------------------------------------------------------X- 190 PER MILL
   110       4    18 |====================================                                                            X
                     |_________|_________|_________|_________|_________|_________|_________|_________|_________|_________|
RELATIVE PIXEL COUNT |                                         50                                        100 PER CENT
```

FOA 356

Causes a window to be symbolcoded. Every graylevel gets a selected symbol. The result is displayed on line printer.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      LOGICAL*1 CODE
      REAL*8 DDNAME,DSNAME
      COMMON/CODE/CODE(256)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1216,20,1461,53,4/
      DATA CODE/15*' ', 1*'1',1*'2',1*'3',1*'4',1*'5',1*'6',1*'7',1*'8',
     2             1*'9',1*'A',1*'B',1*'C',1*'D',1*'E',1*'F',1*'G',1*'H',
     3             1*'I',1*'J',1*'K','L','M','N','O','P','Q','R','S',
     4             'T','U','V',210*' '/
      DATA DDNAME/'DATASET1'/
      END
```

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA CODE/15*' ',1*'1',... ... ...,'u','v',210*' '/ | Means that the 15 first graylevels are 'printed' with blanks, the next with '1' etc. CODE must have 256 values. (1*'u' is the same as 'u'). |

Subroutines in this task:
TGCODE(ENCODE(TGHEAD,INTBYT))

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-06)

LANDSAT:

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-09523OO | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 12968 |

| | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: N584E122 | 1201 | 128 | 1387 | 128 | 4 | 5 | 6 | 7 |
| GRAYLEVEL-CODED SUBSCENE | 1216 | 20 | 1461 | 53 | 4 | 0 | 0 | 0 |

```
7A77976777779AA569999A77DA9FE69DEFEA99EHLJHEDAADAAHHDD
8A88A877868777378AA888AD388878DDGGDADKQGEEEEDDEGEEHDD
LLB9BB939866669CB8986888BB98989B966998BIOIBEEEFECBEINIF
BC87BBBB667767BC88877788878788843667CHJHCBBDFCCCBBJTF
AA7ABBBBA77777A8ABBAA777AB7ABB6535568CKOLGCCCCCDDGGGB
977CDDDGD977779A9DFFF979AC9996444437ACFJFCCDDFFGFDGGJ
99ADFFFEA967799A9ALVSH99637644344469FHFEEEEDDEFD99DEE
AADGHGDEHA778AA8AAKSJOK8446444444467EGHEDDGHDAEHGGHGDD
EFLJFIFFF95689B9BBIIEFE5244444444446BCECB8BCCCEIECCCCC
FFFHJHHFCB7786B7888FF73333333333333468 6BHNFCB8BCDCDDDC
GCGGGCBBBB7AAAAABABBA73333333335335367ACHJHC8CBBBDDDDC
GGDCCCCDDAA99A9799AC974443444443333349CCFJJJDCCCCFFFGK
DAADDADAA99AA79D99D97433443443434469DA9AKKDADDEEEEHF
DAEEAAAAADA88ADLAADEA7444444444444466DDED8DDEHKHGEDDEE
CCCCC89990988988898CC9544444422244246CFEC8BBCECCEFFFII
CBBCCC8878BB887788887CD8633323333333448CCCBCC88CHFCDDC
DCCBCCBBA77A76AAAAAA6CDB6555333333235ADDHDCCCBCCCBDGC
CAADDAA9977779AA999AADDFD744433333349CCDCCCCCDCDDCCF
EDHEFEA97777999A7779EKEEFED7433344436ACADDDEDDDDFKFHH
AAGEDEA8767776887888DHEDDAA84444444446DAAADAAAADDHHGED
```

SYMBOLCODING KEY:
0 GRAYLEVEL 15 25 35 45 55 65 75 85 95 105 115 125

KEY: 123456789ABCDEFGHIJKLMNOPQRSTUV

GRAYLEVEL 145 155 165 175 185 195 205 215 225 235 245 255

KEY:

DATE 76-09-06

COVCORR

Computes mean, standard deviation, covariance and correlation. The correlation coefficients may also be illustrated graphically. One can choose an interval in one channel within which one wants to have the statistics quantities.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      INTEGER*2 IMAGE,NUANCE,
      INTEGER*2 THRSH1,THRSH2,MSCNR
      REAL*8 DDNAME,DSNAME
      COMMON/KOMPS/KOMPS
      COMMON/LAOSAM/KARD(3),LIST(3),LAQSFC(3,5),DDNAME(10)
      COMMON/NUANCE/IMAGE,NUANCE(256,1)
      COMMON/PLOTTG/LINER9,LISTEP,LOSTEP,DASH
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSS3(10)
      COMMON/THRSH/THRSH1,THRSH2,MSCNR
C     COMMON/WORKIN/AREA(KOMPS*KOMPS + 3*KOMPS)
      COMMON/WORKIN/AREA(88)
      COMMON/DISPLA/DISPLA
C
      DATA KOMPS/3/
      DATA THRSH1,THRSH2,MSCNR/15,20,5/
      DATA DSNAME/'URBAN    '/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/566,8,1961,16,4,5,7/           URBAN
      DATA IMAGE/1/
      DATA NUANCE/1,2,3,4,5,6,7,8,2*9,246*1/
      DATA LISTEP,LOSTEP/6,13/
      DATA DISPLA/'DO  '/
      DATA DDNAME/'DATASET1'/
      END
```

| | |
|---|---|
| DATA KOMPS/3/ | Number of channels. |
| DATA THRSH1,THRSH2,MSCNR/15,20,5/ | THRSH1=15 The lower threshold.<br>THRSH2=20 The higher threshold.<br>MSCNR=5 Number of threshold channel.<br>Accordinly, the only pixels which will be processed in the selected channels are those pixels which lie within the interval 15 - 20 in channel 5. |
| DATA DSNAME/'URBAN   '/ | Name of the window. To be given by the user. |
| DATA DISPLA/'DO  '/ | DISPLA='DO  ' causes a graphic display of the correlation coefficents. Use DISPLA='DONT' to avoid graphic display. |

DATA LINE1,... See the description of the source deck.

Subroutines in this task:
COVCOR (TGHEAD,FLOBYT,LINPRT(MAXIMH))

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-27)

LANDSAT:

| SCENE/FRAME ID | EXPOSURE | SCENE CENTER | ORIGINAL | CORIOLISRECTIFIED |
|---|---|---|---|---|
| SDDD-HHMMSSN | DATE; UT | LAT LONG | CCT(S): | LINE LENGTH |
| 1039-09381000 | 31AUG72 C | N47-21/E011-00 | 0 2 3 4 | 3396 |

| INPUT DATASET SUBSCENE: | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| STARNBERG | 239 | 512 | 1689 | 512 | 4 5 0 7 |
| SELECTED SUBSCENE: URBAN | 566 | 8 | 1961 | 16 | 4 5 0 7 |

ONLY PIXELS WITHIN THE INTERVAL ( 15- 20, MSSBAND 5) HAVE BEEN USED

ESTIMATED MEAN AND STANDARD DEVIATION VECTORS:

| | | |
|---|---|---|
| 4 | 2.374193E+01 | 7.172198E-01 |
| 5 | 1.732257E+01 | 1.503089E+00 |
| 7 | 2.128226E+01 | 1.089270E+00 |

ESTIMATED COVARIANCE (DIAGONAL AND UPPER RIGHT) AND CORRELATION (LOWER LEFT) MATRICES:

| | 4 | 5 | 7 |
|---|---|---|---|
| 4 | 5.144[illegible]43E-01 | 5.195436E-01 | 2.019943E-01 |
| 5 | 4.001466[illegible]E-01 | 2.259277E+00 | 3.500895E-01 |
| 7 | 2.564[illegible]73E-01 | 2.17655[illegible]E-01 | 1.180523E+00 |

THE NUMBER OF REPRESENTATIVES EXTRACTED FROM THIS MULTISPECTRALLY IMAGED OBJECT FOR EVALUATION OF STATISTICS QUANTITIES IS 124

```
                             7
 4
 4
 4
 4
 4
 4
 5     8BEEBEBEBB
 5     BEEBBBBEBB
 5     BEBEEBBEBB
 5     BEBBBBEBBB
 5     BBBBBBBBEE
 5     BBBBBBBBBB
 7     1111111111----------
 7     1111111111----------
 7     1111111111----------
 7     1111111111----------
 7     1111111111----------
 7     1111111111----------
```

4: 500 - 600 NANOMETERS
5: 600 - 700 NANOMETERS
6: 700 - 800 NANOMETERS
7: 800 - 1100 NANOMETERS

DATE 76-07-27

HEXPIXEL

Prints pixel intensity in hexadecimal form of one or several channels. Optional versions of subroutine MSSDAT allow lumping in groups of all selected channels for each pixel (example 1) or all pixels for each selected channel (example 2) respectively.

Example 1.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1241,5,1448,8,4,5,6,7/
      DATA DDNAME/'DATASET1'/
      END
```

Example 2.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/ 306,  16,1365,  16,4,5,6,7/
      DATA DDNAME/'DATASET1'/
      END
```

DATA LINE1,... — See the description of the source deck.

Subroutines in this task:
MSSDAT(TGHEAD,HEXBYT),LAMBDA

Example 1.

```
276-HEXPIXEL PAGE    14

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-12)

LANDSAT:

SCENE/FRAME ID : EXPOSURE  SCENE CENTER     ORIGINAL  CORIOLISRECTIFIED
 SDDD-HHMMSBN    DATE; UT   LAT   LONG       CCT(S):     LINE LENGTH
 1330-0952300   18JUN73 C N58-41/E012-23    1 2 3 4         3240

INPUT DATASET SUBSCENE:          LINE1     LINES    LOCUS1      LOCI     OF MSSBANDS
      ORSJON                     1201       128      1387        128     4  5  6  7
MSSDATA SUBSCENE                 1241         5      1448          8     4  5  6  7


14081COF 150C1E10 150C1E11 150C1C10 150C1C10 140C1COF 14081A0F 150C1F13
140D1COF 140D1C10 160E1COF 160D1C11 140D1COF 140B190F 140B180F 130D1COF
140B190F 140C1C11 14081E10 14081C10 14081A0E 120A190E 140B190E 140C1E10
140C1810 140D1D12 150D2012 150C1D10 140C1B0F 140D180F 140C180F 150D1D11
15081D11 150C1D11 15081F11 15081F11 15081D11 150C1F11 15081D11 14081F10
```

ORIGINAL PAGE IS
OF POOR QUALITY

Example 2.

```
401-HEXPIXEL PAGE    14

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-14)

LANDSAT:

SCENE/FRAME ID    EXPOSURE   SCENE CENTER       ORIGINAL   CORIOLISRECTIFIED
 SDDD-HHMMSBN     DATE; UT    LAT    LONG        CCT(S):      LINE LENGTH
 1039-0938100     31AUG72 C N47-21/E011-00      0 2 0 0          3396

INPUT DATASET SUBSCENE:          LINE1     LINES    LOCUS1      LOCI      OF MSSBANDS
      N472E110                    306       256      1365        256        4  5  6  7
MSSDATA SUBSCENE                  306        16      1365         16        4  5  6  7

<------------ MSS4 ------------>|<------------ MSS5 ------------>|<------------ MSS6 ------------>|<------------ MSS7 ------------>

14141616161614161716141416161618 0D0E0F0E0E0F0E0E0F0E0D0D0E0E0E10 19191A191A1C191A23231C171C1F282A 0E0F0F0D0E0F0E101514100E1014181B
12131414171713141714171714141418 0B0B0E0E0E0E0B0C0E0E0E0F0E0C0E12 151B1C1B1B1C17222220282A2624222C 0D0F1110101 10E1515131818161 5151E
13141417141713171414171918171718 0B0C0D0D0E0D0C0C0D0D0D100E0D0D0E 191C1C1E1C1C191C1C1E2C3A37281F2C 0E11121311 0F0F10101220272318141E
14141314141413141714141819171417 0C0C0C0D0D0E0C0E0D0C000F0F0D0D0D 1A1E1D1E201D1A1A1E1C2837372A2428 1112101212100D1010101A26251D1518
1313141414131414141313141618181A 0C0B0C0C0B0C0C000D0B0B0D0D0D0E13 131B1D1D18171A131315181F2A202030 0F0E10110D0C0E100E0B0C141B1D1B1B
1314131314131414141414161414181A 0C0C0B0B0B0B0C0B0C0C0C0C0C0E0F0F 1B191516161818181516191B1B22363E 100E0C0C0D0D0E0D0C0D0E1110162426
16141416141414141416161618181617 0E0D0B000D0E0B0D0D0D000E100F0E0F 1C1917191A1917171A1F1E1C232C2A2C 100D0E0D0E0F0D0D111413101 41A191C
17131314141312131313141313141814 0E0B0C0C0B0B0B0B0A0B0C0E0C0C110E 1C171C1C1C1B191B1B1C181917222A26 100E111112110F111011110F0D141A18
14131414141314131313131417181817 0C0B0D0C0C0C0C0C0B0C0B0B0E100E0D 17171C1C1E1C1C1C1C1A17171E232521 0D0E121212121111110F0C0E12161714
13131413141314141414131413131714 0B0B0C0C0B0B0C0C0B0C0B0B0C0C0D0D 15171C1E1C181D1C1A1A1A17171C2224 0D0E1012100E1210100F0E0D0C111516
14131414131414141414141413141613 0B0B0B0B0C0D0D0D0C0C0C0B0B0D0E0B 1F1A181B1A221F1D1B1B181B181D1F15 100D0E0F0E1311100F0F100F0F12100B
1414141314141314141413141414181A 0C0B0C0C0D0C0B0B0B0C0D0C0C0C1314 181919181D19181818191D1D101D2024 100E0E0E120E0D0E0E0F111212111315
13131316171313131316161616131317 0C0C0B0E0E0B0B0C0C0C0E0E0E0C0C10 171A191E1F1A16191A1E25251E1A191E 0D0F0E12140E0C000F121516120E0E11
13121313131313141414131414131314 0C0A0B0B0C0E0B0C0E0C0C0C0E0C0B0C 19191B191C181B1E22221E20221C181C 0F0E11101210101215161212151110 12
18131313141314141717171413141414 0E0B0C0B0C0C0D0D0E0E0E0D0C0C0C0C 1E1A191C1A1C1C1E23231F1E1C1A1E1E 10100F10101111111614121310111212
13121313141717171714141714141413 0B0B0C000C0D0E000D0C000D0D000B0B 1A171D1D1E22202228201E201E1E1A1C 0F0C1212131514161712121211100E11

SUMMER-SCHOOL ALPBACH 1976
PRACTICAL APPLICATION OF REMOTE SENSING
WORKSHOP 4A: DIGITAL PROCESSING TECHNIQUES
ORHAUG/FOA355 1976

DATE 76-07-14
```

PROJEC2D

Plots 2-dimensional projection(s) of the distribution of the pixels in n-dimensional space on CALCOMP. (LANDSAT, n=4)

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1149,23,1421,24,4,5,7/
      DATA DDNAME/'DATASET1'/
      END
```

DATA LINE1,...  See the description of the source deck.

Subroutines in this task:
MFPROJ(TGHEAD)

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-16)

LANDSAT:

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-0952300 | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 3358 |

| | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: KROPPEFJ | 1073 | 256 | 1348 | 256 | 4 5 6 7 |
| 2-D PROJECTED SUBSCENE: | 1149 | 23 | 1421 | 24 | 4 5 0 7 |

LAKE

KROPPEFJALL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

DATE 76-09-16

IMAGE GENERATION AND MANIPULATION

FOA 355

Generates a window on the line printer with the use of nine printer graylevels.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      INTEGER*2 IMAGE,NUANCE
      COMMON/NUANCE/IMAGE,NUANCE(256,3)
      COMMON/PLOTTG/LINER8,LISTEP,LOSTEP,DASH
C
      DATA NUANCE/19*9,2*8,2*7,6,5,2*4,3,2*2,226*1/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1216,20,1461,53,4/
      DATA LINER8,LISTEP,LOSTEP/'EACH',1,1/
      DATA DDNAME/'DATASET1'/
      END
```

DATA NUANCE/19*9,2*8,2*7,6,...,226*1/ — The pixels having one of the 19 lowest digital values (0, 1,...,18) get the printer graylevel 9 (corresponding to black), the next two get printer graylevel 8 etc. The last 226 values get printer graylevel 1 (white). NUANCE must have 256 values.

DATA LINE1,... — See the description of the source deck.

DATA LINER8,LISTEP,LOSTEP/'EACH',1,1/ — If LINER8 has not been assigned the value 'EACH' an 'interpolation' reduction of the number of output lines is performed to compensate for the rectangular form of the line printer characters.
If LISTEP=1 and LOSTEP=1, every line and every pixel per line are printed.

Subroutines in this task:

TGPRNT(LNPRNT(TGHEAD,INTBYT,MAXIMH,NUANCT))

42.

```
TASK DOCUMENTATION LOG FOR F0A355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-06)

LANDSAT:

SCENE/FRAME ID    EXPOSURE   SCENE CENTER       ORIGINAL   CORIOLISRECTIFIED
 SDDD-HHMMSSN     DATE; UT    LAT    LONG        CCT(S):      LINE LENGTH
 1330-0952300     18JUN73 C N58-41/E012-23       1 2 3 4         12968

INPUT DATASET SUBSCENE:        LINE1     LINES     LOCUS1      LOCI     OF MSSBANDS
      N584E122                  1201      128       1387        128      4  5  6  7
LINEPRINTER SUBSCENE:           1216       20       1461         53      4  0  0  0    EVERY 1 LINES, EVERY 1 LOCI

DUE TO THE SELECTED LINERATE "EACH" THERE WILL BE  20 LINES AND  53 LOCI IN THE LINEPRINTER IMAGE

     DATA NUANCE/ 19* 9,  2* 8,  2* 7,  1* 6,  1* 5,  2* 4,  1* 3,
    2              2* 2,226* 1/
```

DATE 76-09-06

CALCOMP

Generates a window on the microfilm plotter with use of the 16 plot graylevels 10 - 25.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      REAL*8 DDNAME,DSNAME
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/PLOTTG/LINERB,LISTEP,LOSTEP,DASH
      INTEGER*2 IMAGE,NUANCE
      COMMON/NUANCE/IMAGE,NUANCE(256,4)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/239,512,1689,512,5/
      DATA NUANCE/11*25,24,22,20,19,17,15,2*14,2*12,235*10/
      DATA LISTEP,LOSTEP,DASH/4,3,10./
      DATA DDNAME/'DATASET1'/
      END
```

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA NUANCE/11*25,...,235*10/ | The 11 lowest values a pixel can have get the plot graylevel 25, the next get plot graylevel 24 etc. NUANCE must have 256 levels. |
| DATA LISTEP,LOSTEP,DASH/4,3,10./ | Each input pixel will be represented by a 4*3(LISTEP*LOSTEP) matrix of output pixels of uniform intensity.<br>DASH=10. The length in input pixels of a line segment and of the gap in the dashed line used as a frame surrounding the plotted window. |

Subroutines in this task:

TGPLOT (MFPLOT(TGHEAD),FRAME)

338-CALCOMP PAGE 16

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-23)

LANDSAT:

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; JT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1039-0938100 | 31AUG72 C | N47-21/E011-00 | 0 2 3 4 | 3396 |

| | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: STARNBRG | 239 | 512 | 1689 | 512 | 4 5 0 7 |
| MICROFILMED SUBSCENE: | 239 | 512 | 1689 | 512 | 0 5 0 0 |

DATA NUANCE/ 11*25, 1*24, 1*22, 1*20, 1*19, 1*17, 1*15,
2 2*14, 2*12,235*10/

SUMMER-SCHOOL ALPBACH 1976
PRACTICAL APPLICATION OF REMOTE SENSING
WORKSHOP 44: DIGITAL PROCESSING TECHNIQUES
ORHAUG/FOA355 1976

DATE 76-07-23

INKJETS

Generates a color image on paper or transparency using one or more of three possible ink colors. Presently the image is generated on tape at the Stockholm Computer Center and subsequently imaged at FOA 355. Colors can be assigned as an object identification color code (example 3) or as intensity modulated false colors for up to three separate wavelength band images (example 4). The three base colors used are yellow, magenta and cyan - usually in that order for increasing wavelength of the multispectral band imaged since the color mixing is of the so called subtractive type. Resulting color mixtures - in theory - using no ink (0) and full (15) ink intensity are as indicated in table 1.

Table 1. Color generation table for the inkjet plotter.

| 'subtractive' ink | Y | M | C | 'theorical' image color |
|---|---|---|---|---|
| | 0 | 0 | 0 | white |
| | 15 | 0 | 0 | yellow |
| | 0 | 15 | 0 | magenta |
| intensity | 0 | 0 | 15 | cyan |
| | 15 | 15 | 0 | red |
| | 15 | 0 | 15 | green |
| | 0 | 15 | 15 | blue |
| | 15 | 15 | 15 | black |

```
      BLOCK DATA
C     FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DSNAME,DDNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/PLOTTG/LINERB,LISTEP,LOSTEP,DASH
      INTEGER*2 IMAGE,NUANCE
      COMMON/NUANCE/IMAGE,NUANCE(256,3)
      COMMON/MSSINK/MSSY,MSSC,MSSM
C
      DATA DSNAME/'INKJETIM'/
      DATA MSSY,MSSC,MSSM/6,3,9/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/ 1315,183,257,132,3,6,9/
      DATA NUANCE/ 5*15,14,13,12,11,10,9,8,7,6,5,4,3,2,233*1,
     2            8*15,14,13,12,11,10,9,8,7,6,5,4,2*3,4*2,231*1,
     3            2*13,14,13,12,7*11,3*10,3*9,2*8,2*7,4*6,3*5,3*4,3,2,
     4            222*1/
      DATA LISTEP,LOSTEP,DASH/6,6,10./
      DATA DDNAME/'DATASETI','DATASETI','DATASETI','INKIMAGE'/
      END
```

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OF POOR QUALITY

| | |
|---|---|
| DATA MSSY,MSSC,MSSM/6,3,9/ | MSSY=6 Channel 6 is yellow.<br>MSSC=3 Channel 3 is cyan.<br>MSSM=9 Channel 9 is magenta. |
| DATA LINE1,... | See the description of the source deck. |
| DATA NUANCE/5*15,14,...<br>...,3,2,222*1/ | See example 4. |
| DATA LISTEP,LOSTEP,DASH/6,6,10./ | Each input pixel will be represented by a 6*6(LISTEP*LOSTEP) matrix of output pixels of uniform intensity.<br>DASH=10. (has presently no function in this task). |

Subroutines in this task:
INKJET(BYTINT,TGHEAD,NUANCT,JETSET(INTBYT))

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-07-16)

```
MSS-75:

SCENE IDENTIFICATION          REG. DATE UT HH MM SS  MS
SU750304 LARSTAVIKEN           04/07/75    12  7 34 158

INPUT DATASET SUBSCENE:        LINE1    LINES    LOCUS1    LOCI    OF MSSBANDS
      LARSTVKN                  1315     183      257       132     0 0 3 4 5 6 7 8 9 10
SUBSCENE SELECTED FOR YELLOW    1315     183      257       132       MSS 6
      DATA NUANCE/  5*15,  1*14,  1*13,  1*12,  1*11,  1*10,  1* 9,
    2               1* 8,  1* 7,  1* 6,  1* 5,  1* 4,  1* 3,  1* 2,
    3             238*.1/


INPUT DATASET SUBSCENE:        LINE1    LINES    LOCUS1    LOCI    OF MSSBANDS
      LARSTVKN                  1315     183      257       132     0 0 3 4 5 6 7 8 9 10
SUBSCENE SELECTED FOR CYAN      1315     183      257       132       MSS 3
      DATA NUANCE/  8*15,  1*14,  1*13,  1*12,  1*11,  1*10,  1* 9,
    2               1* 8,  1* 7,  1* 6,  1* 5,  1* 4,  2* 3,  4* 2,
    3             231* 1/


INPUT DATASET SUBSCENE:        LINE1    LINES    LOCUS1    LOCI    OF MSSBANDS
      LARSTVKN                  1315     183      257       132     0 0 3 4 5 6 7 8 9 10
SUBSCENE SELECTED FOR MAGENTA   1315     183      257       132       MSS 9
      DATA NUANCE/  2*15,  1*14,  1*13,  1*12,  7*11,  3*10,  3* 9,
    2               2* 8,  2* 7,  4* 6,  3* 5,  3* 4,  1* 3,  1* 2,
    3             222* 1/

EACH ORIGINAL PIXEL PLOTTED AS A UNIFORM  6* 6 INKJET PIXEL MATRIX. THE INKJET IMAGE THEREFORE HAS 1098 INK-LINES AND  792 INK-LOCI

DATE 76-07-16
```

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Example 3.

To do a color image of only one channel of a classified image (with type objects identified by numbers) e.g. a 4 x 4 window:

| | | | |
|---|---|---|---|
| 0 | 1 | 2 | 1 |
| 7 | 10 | 10 | 3 |
| 1 | 1 | 10 | 3 |
| 5 | 5 | 10 | 10 |

We want the digital values to correspond pairwise to a specific color, 0 and 1 (blue), 2 and 3 (green), 4 and 5 (yellow), 6 and 7 (red), 8 and 9 (light red) and 10 (black).

According to table 1, blue is a combination of magenta and cyan. Using full ink intensities digital level 0 and 1 must have no yellow, but equal amounts of magenta and cyan. (table 2).

Table 2.

| | Digital value | Ink color Y | M | C |
|---|---|---|---|---|
| Blue | 0 | 0 | 15 | 15 |
| | 1 | 0 | 15 | 15 |
| Green | 2 | 15 | 15 | 0 |
| | 3 | 15 | 15 | 0 |
| Yellow | 4 | 15 | 0 | 0 |
| | 5 | 15 | 0 | 0 |
| Red | 6 | 15 | 0 | 15 |
| | 7 | 15 | 0 | 15 |
| Light red | 8 | 7 | 0 | 7 |
| | 9 | 7 | 0 | 7 |
| Black | 10 | 15 | 15 | 15 |
| White | 11-255 | 0 | 0 | 0 |

Every column must consist of 256 values

Table 2 is then converted color by color to:

```
DATA NUANCE/2*0,6*15,2*7,15,245*0,        MSSY
            4*15,6*0,15,245*0,            MSSM
            2*15,4*0,2*15,2*7;15,245*0/   MSSC
```

MSSY is obtained by assigning 'graylevels' to column Y and so on.

Example 4.

To do an intensity modulated false color image with three separate channels.

Do as if simultaneously generating three black and white line printer images (task FOA 355) and put them together in NUANCE. In NUANCE the channels must be ordered as in the variables MSSY, MSSM, MSSC by which one assigns desired channel numbers to the appropriate ink color. (Note that the colors in the exemplifying BLOCK DATA and in the task documentation sheet are erroneously ordered.)

RAMTEK

Transferral of a window from disk dataset to tape for subsequent display on the Ramtek TV-monitor. The Ramtek system allows generation of so called pseudocolor or false color images (color mixing by the additive principle).

```
      BLOCK DATA
C     FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DSNAME,DDNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/PLOTTG/LINER8,LISTEP,LOSTEP,DASH
      INTEGER*2 IMAGE,NUANCE
      COMMON/NUANCE/IMAGE,NUANCE(256,3)
      COMMON/RAMTEK/LINWDS(160)
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1390,600,150,300,5/
      DATA LISTEP,LOSTEP,DASH/1,1,10./
      DATA DDNAME/'DATASETI','DATASETO'/
      END
```

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA LISTEP,LOSTEP,DASH/1,1,10./ | Each input pixel will be represented by a 1*1 (LISTEP*LOSTEP) matrix of output pixels of uniform intensity, i.e. one input pixel gives one output pixel. (DASH=10. has presently no function in this task.) |

Subroutines in this task:

TGRTEK (TGRBW(BYTINT,NUANCT,RAMSET))

507-RAMTEK PAGE 16

SCENE IDENTIFICATION LOG FOR FOA355 MSS-75 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE

SCENE IDENTIFICATION REG. DATE UT HH MM SS MS
I A K 0 K E.

| INPUT DATASET SUBSCENE: | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| SU75010A | 1390 | 600 | 150 | 300 | 0 0 0 0 5 0 0 8 0 10 |
| RAMTEK B/W SUBSCENE:DATASET0 | 1390 | 600 | 150 | 300 | 0 0 0 0 5 0 0 0 0 0 |

EACH ORIGINAL PIXEL PLOTTED AS A UNIFORM 1* 1 RAMTEK PIXEL MATRIX. THE RAMTEK IMAGE THEREFORE HAS 600 LINES AND 300 LOCI

RAMTEK, CLASSIFIED IMAGE, ULTUNA

DATE 76-05-25

MOVE

Move a window from a disk dataset to another disk dataset. The possibility to halve the values of the pixels exists.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      LOGICAL*1 CODE
      REAL*8 SELECT
      REAL*8 DDNAME,DSNAME
      COMMON/CODE/CODE(256)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/COMPR /SELECT
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1150,20,1250,40,5,7/
      DATA DDNAME/'DATASETI','DATASETO'/
      DATA SELECT/'COMPRESS'/
      DATA CODE  /2*Z00,2*Z01,2*Z02,2*Z03,2*Z04,2*Z05,2*Z06,2*Z07,2*Z08,
     22*Z09,2*Z0A,2*Z0B,2*Z0C,2*Z0D,2*Z0E,2*Z0F,2*Z10,2*Z11,2*Z12,2*Z13,
     32*Z14,2*Z15,2*Z16,2*Z17,2*Z18,2*Z19,2*Z1A,2*Z1B,2*Z1C,2*Z1D,2*Z1E,
     42*Z1F,2*Z20,2*Z21,2*Z22,2*Z23,2*Z24,2*Z25,2*Z26,2*Z27,2*Z28,2*Z29,
     52*Z2A,2*Z2B,2*Z2C,2*Z2D,2*Z2E,2*Z2F,2*Z30,2*Z31,2*Z32,2*Z33,2*Z34,
     62*Z35,2*Z36,2*Z37,2*Z38,2*Z39,2*Z3A,2*Z3B,2*Z3C,2*Z3D,2*Z3E,2*Z3F,
     72*Z40,2*Z41,2*Z42,2*Z43,2*Z44,2*Z45,2*Z46,2*Z47,2*Z48,2*Z49,2*Z4A,
     82*Z4B,2*Z4C,2*Z4D,2*Z4E,2*Z4F,2*Z50,2*Z51,2*Z52,2*Z53,2*Z54,2*Z55,
     92*Z56,2*Z57,2*Z58,2*Z59,2*Z5A,2*Z5B,2*Z5C,2*Z5D,2*Z5E,2*Z5F,2*Z60,
     12*Z61,2*Z62,2*Z63,2*Z64,2*Z65,2*Z66,2*Z67,2*Z68,2*Z69,2*Z6A,2*Z6B,
     22*Z6C,2*Z6D,2*Z6E,2*Z6F,2*Z70,2*Z71,2*Z72,2*Z73,2*Z74,2*Z75,2*Z76,
     32*Z77,2*Z78,2*Z79,2*Z7A,2*Z7B,2*Z7C,2*Z7D,2*Z7E,2*Z7F/
      END
```

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA SELECT/'COMPRESS'/ | If SELECT='COMPRESS', every value will be divided by two. |

Subroutines in this task:

TGSEL(SELECT(TGHEAD,BYTINT,INTBYT))

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-06)

LANDSAT:

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-0952300 | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 3240 |

| | | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: | ORSJON | 1073 | 128 | 1240 | 200 | 4 5 6 7 |
| TRANSFERED SUBSCENE | | 1150 | 20 | 1250 | 40 | 0 5 0 7 |

ALL VALUES OF THE PIXELS HAVE BEEN DIVIDED BY 2

DATE 76-09-06

COMPOUND

Calculate the difference or the sum between two channels. For other expressions one must insert the appropriate program statements in subroutine OPTION.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      LOGICAL*1 DIVTAB,DIVGO
      LOGICAL*1 B1WORK(512)
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
C
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      INTEGER*2 IM1,IM2,SIGN
      COMMON /EXPR/ IM1,SIGN,IM2
      COMMON /TAB/ DIVTAB(414),DIVGO(98)
      COMMON/WORK/B1WORK
C
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1103,61,1291,100,5,7/
      DATA IM1,SIGN,IM2/7,'-',5/
      DATA DDNAME/'DATASETI','DATASETO'/
      DATA DIVTAB/2*Z00,2*Z01,2*Z02,2*Z03,2*Z04,2*Z05,2*Z06,2*Z07,2*Z08,
     22*Z09,2*Z0A,2*Z0B,2*Z0C,2*Z0D,2*Z0E,2*Z0F,2*Z10,2*Z11,2*Z12,2*Z13,
     32*Z14,2*Z15,2*Z16,2*Z17,2*Z18,2*Z19,2*Z1A,2*Z1B,2*Z1C,2*Z1D,2*Z1E,
     42*Z1F,2*Z20,2*Z21,2*Z22,2*Z23,2*Z24,2*Z25,2*Z26,2*Z27,2*Z28,2*Z29,
     52*Z2A,2*Z2B,2*Z2C,2*Z2D,2*Z2E,2*Z2F,2*Z30,2*Z31,2*Z32,2*Z33,2*Z34,
     62*Z35,2*Z36,2*Z37,2*Z38,2*Z39,2*Z3A,2*Z3B,2*Z3C,2*Z3D,2*Z3E,2*Z3F,
     72*Z40,2*Z41,2*Z42,2*Z43,2*Z44,2*Z45,2*Z46,2*Z47,2*Z48,2*Z49,2*Z4A,
     82*Z4B,2*Z4C,2*Z4D,2*Z4E,2*Z4F,2*Z50,2*Z51,2*Z52,2*Z53,2*Z54,2*Z55,
     92*Z56,2*Z57,2*Z58,2*Z59,2*Z5A,2*Z5B,2*Z5C,2*Z5D,2*Z5E,2*Z5F,2*Z60,
     12*Z61,2*Z62,2*Z63,2*Z64,2*Z65,2*Z66,2*Z67,2*Z68,2*Z69,2*Z6A,2*Z6B,
     22*Z6C,2*Z6D,2*Z6E,2*Z6F,2*Z70,2*Z71,2*Z72,2*Z73,2*Z74,2*Z75,2*Z76,
     32*Z77,2*Z78,2*Z79,2*Z7A,2*Z7B,2*Z7C,2*Z7D,2*Z7E,2*Z7F,2*Z80,2*Z81,
     42*Z82,2*Z83,2*Z84,2*Z85,2*Z86,2*Z87,2*Z88,2*Z89,2*Z8A,2*Z8B,2*Z8C,
     52*Z8D,2*Z8E,2*Z8F,2*Z90,2*Z91,2*Z92,2*Z93,2*Z94,2*Z95,2*Z96,2*Z97,
     62*Z98,2*Z99,2*Z9A,2*Z9B,2*Z9C,2*Z9D,2*Z9E,2*Z9F,2*ZA0,2*ZA1,2*ZA2,
     72*ZA3,2*ZA4,2*ZA5,2*ZA6,2*ZA7,2*ZA8,2*ZA9,2*ZAA,2*ZAB,2*ZAC,2*ZAD,
     82*ZAE,2*ZAF,2*ZB0,2*ZB1,2*ZB2,2*ZB3,2*ZB4,2*ZB5,2*ZB6,2*ZB7,2*ZB8,
     92*ZB9,2*ZBA,2*ZBB,2*ZBC,2*ZBD,2*ZBE,2*ZBF,2*ZC0,2*ZC1,2*ZC2,2*ZC3,
     12*ZC4,2*ZC5,2*ZC6,2*ZC7,2*ZC8,2*ZC9,2*ZCA,2*ZCB,2*ZCC,2*ZCD,2*ZCE/
      DATA DIVGO/
     22*ZCF,2*ZD0,2*ZD1,2*ZD2,2*ZD3,2*ZD4,2*ZD5,2*ZD6,2*ZD7,2*ZD8,2*ZD9,
     32*ZDA,2*ZDB,2*ZDC,2*ZDD,2*ZDE,2*ZDF,2*ZE0,2*ZE1,2*ZE2,2*ZE3,2*ZE4,
     42*ZE5,2*ZE6,2*ZE7,2*ZE8,2*ZE9,2*ZEA,2*ZEB,2*ZEC,2*ZED,2*ZEE,2*ZEF,
     52*ZF0,2*ZF1,2*ZF2,2*ZF3,2*ZF4,2*ZF5,2*ZF6,2*ZF7,2*ZF8,2*ZF9,2*ZFA,
     62*ZFB,2*ZFC,2*ZFD,2*ZFE,2*ZFF/
      END
```

| | |
|---|---|
| DATA LINE1,... | See the description of the source deck. |
| DATA IM1,SIGN,IM2/7,'-',5/ | IM1 and IM2 number of channels. SIGN='-' or '+'. /7,'-',5/ means therefore channel 7 minus channel 5. |

Subroutines in this task:

COMPOZ(TGHEAD,BYTINT,OPTION)INTBYT))

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TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-02)

LANDSAT:

| SCENE/FRAME ID SDDD-HHHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-0952300 | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 3240 |

| | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| INPUT DATASET SUBSCENE: ÖRSJÖN | 1073 | 128 | 1240 | 200 | 4 5 6 7 |
| MSSDATA SUBSCENE | 1103 | 61 | 1291 | 100 | |

DATE 76-09-02

TRAINING AND CLASSIFICATION

TYPEHEAD

Initiating a type-object library.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/KOMPS/KOMPS
      COMMON/MSTYPE/ MSTYPE,MSCMIN,MSCMAX
C
      DATA DSNAME/'N584E122'/
      DATA MSTYPE,MSCMIN,MSCMAX/1,4,7/
      DATA KOMPS /3/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1073,256,1343,256,4,5,7/
      DATA DDNAME/'DATASET0'/
      END
```

| | |
|---|---|
| DATA DSNAME/'N584E122'/ | DSNAME is the name of the scene to be classified (constructed in a prescribed manner from the geographic coordinates - here N58-41/E012-23 - for the scene center). |
| DATA MSTYPE,MSCMIN,MSCMAX/1,4,7/ | MSTYPE=1 For LANDSAT.<br>MSTYPE=2 For MSS-75.<br>MSTYPE=3 For VHRR.<br>MSCMIN Lowest channel number.<br>MSCMAX Highest channel number. |
| DATA KOMPS/3/ | KOMPS Number of channels. |
| DATA LINE1,... | See the description of the source deck. |

Subroutines in this task:

BYTINT

984 TYPEHEAD PAGE

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-14)

INITIATING TYPE-CLASS TRAINING-LIBRARY FILE:N584E122

KROPPEFJALL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

DATE 76-09-14

TYPELIB

Stores original digital data from type-objects for further use in maximum likelihood classification. The type-object does not have to be rectangular, not even connected, but can be any number of arbitrarily formed areas chosen by using mask(s) or produced by using thresholds in one channel as determined with the aid of the HISTOGR task.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
      LOGICAL*1 PIXEL
C
C    IN PIXEL(X), X MUST NOT BE LESS THAN LINES*LOCI*(NUMBER OF CHANNELS)
      COMMON/PIXEL/ PIXEL(2500)
      INTEGER*2 OBJNR,AREANR,CODE
      COMMON/PARAM/ OBJNME,OBJNR,AREANR,CODE
      INTEGER*2 SELECT,MASK
      COMMON /VEK/ SELECT,MASK(400)
      INTEGER*2 THRSH1,THRSH2,MSCNR
      COMMON /THRSH/ THRSH1,THRSH2,MSCNR
      REAL*8 DDNAME,DSNAME,OBJNME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
C
C    SELECT=0 (FOR USING THRESHOLDS)
C    SELECT=1 (FOR USING MASK)
C OBJNR=NUMBER OF THE TYPE-OBJECT TO BE ENTERED
C AREANR=NUMBER OF THE TYPE-OBJECT SUBAREA TO BE ENTERED
C    CODE=1 (NEW TYPE-CLASS AND NEW AREA)
C    CODE=2 (NEW AREA)
C    CODE=3 (DELETE AN AREA)
C    CODE=4 (DELETE A TYPE-CLASS)
C
      DATA SELECT /0/
      DATA MASK/5*1,0,1,0/
      DATA OBJNME,OBJNR,AREANR,CODE/'PINE    ',5,2,2/
      DATA LINE1,LINES,LOCUS1,LOCI,MSSB/1297,   4,1453,    4,4,5,7/
      DATA THRSH1,THRSH2,MSCNR/0,255,4/
      DATA DDNAME/'LIBRARY ','TEMPORAR','DATASET1','PRINTER '/
      END
```

| | |
|---|---|
| COMMON/VEK/SELECT,MASK(x) | x must not be less than LINES* *LOCI when SELECT=1. |
| COMMON/PIXEL/PIXEL(x) | x must not be less than LINES* *LOCI* (number of channels). |
| DATA SELECT/0/ | SELECT=0 For thresholds in channel MSCNR. |
| | SELECT=1 For mask (punched matrix of zeroes and ones). |

| | |
|---|---|
| DATA MASK/5*1,0,1,0/ | If SELECT=1, punch 1 if the pixel shall be counted, otherwise 0. A matrix 1 1 1 1 / 1 0 1 0 corresponds to DATA MASK of the form 5*1,0,1,0. |
| DATA OBJNME,OBJNR,AREANR,CODE/ /'PINE ',5,2,2/ | OBJNME Name of the type-object to be entered. |
| | OBJNR Number of the type-object to be entered. |
| | AREANR Number of the type-object subarea to be entered. |
| | CODE=1 New type-object and new area. |
| | CODE=2 New subarea. |
| | CODE=3 Delete an area. |
| | CODE=4 Delete a type-object. |
| DATA LINE1,... | See the description of the source deck. |
| DATA THRSH1,THRSH2,MSCNR/0,255,4/ | THRSH1=0 The lower threshold. |
| | THRSH2=255 The higher threshold. |
| | MSCNR=4 Number of the channel. |
| | With these threshold parameters all pixels within the selected window are accepted as belonging to the type object. |

Subroutines in this task:
REORG(INTBYT,STATIN(INTBYT,TGHEAD))

TASK DOCUMENTATION LOG FOR F04355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-14)

LANDSAT:

| SCENE/FRAME ID SDDD-HHMMSBN | EXPOSURE DATE; UT | SCENE CENTER LAT LONG | ORIGINAL CCT(S): | CORIOLISRECTIFIED LINE LENGTH |
|---|---|---|---|---|
| 1330-0952300 | 18JUN73 C | N58-41/E012-23 | 1 2 3 4 | 3358 |

| INPUT DATASET SUBSCENE: | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
|---|---|---|---|---|---|
| KROPPEFJ | 1073 | 256 | 1348 | 256 | 4 5 6 7 |

TYPE LIBRARY: N584E122 4 5 0 7 OBJS: 5 KOMPS: 3

| OBJECT NAME | PIXELS *KOMPS | OBJECT NUMBER | AREAS | LINE1 | LINES | LOCUS1 | LOCI | THRES-HOLD 1 | THRES-HOLD 2 | THRESHOLD BAND | PIXELS *KOMPS | AREA NUMBER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLEARC73 | 129 | 1 | 1 | 1301 | 9 | 1467 | 8 | 22 | 25 | 4 | 129 | 1 |
| CLEARC72 | 66 | 2 | 1 | 1292 | 4 | 1445 | 8 | 22 | 24 | 4 | 66 | 1 |
| REGROW11 | 69 | 3 | 1 | 1303 | 6 | 1480 | 5 | 22 | 26 | 7 | 69 | 1 |
| REGROW16 | 60 | 4 | 1 | 1302 | 5 | 1475 | 5 | 18 | 23 | 7 | 60 | 1 |
| PINE | 96 | 5 | 2 | 1291 | 4 | 1483 | 4 | 0 | 255 | 4 | 48 | 1 |
| | | | | 1297 | 4 | 1453 | 4 | 0 | 255 | 4 | 48 | 2 |

KROPPEFJÄLL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

DATE 76-09-14

KEYHEAD

Initiating a type-object key-library.

```
      BLOCK DATA
C   FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DDNAME,DSNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/KOMPS/MSTYPE,KOMPS
C
      DATA DSNAME/'N584E122'/
      DATA MSTYPE,KOMPS/1,3/
      DATA MSSB/4,5,7/
      DATA DDNAME/'KEYLIB  '/
      END
```

| | |
|---|---|
| DATA DSNAME/'N584E122'/ | DSNAME is the name of the scene to be classified (cf. TYPEHEAD). |
| DATA MSTYPE,KOMPS/1,3/ | MSTYPE=1 For LANDSAT. |
| | MSTYPE=2 For MSS-75. |
| | MSTYPE=3 For VHRR. |
| | KOMPS Number of channels. |
| DATA MSSB/4,5,7/ | MSSB(1),... Selected channel numbers. |

Subroutines in this task:

BYTINT

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-14)

INITIATING TYPE-CLASS KEY-LIBRARY FILE:N5B4E122

KROPPEFJALL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

DATE 76-09-14

INTRAKEY

Evaluates initial type-object statistics quantities in a library called KEYLIB to be used for maximum likelihood classification.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      INTEGER*4 OBJEC
      REAL*8 DDNAME,EPS,OBJNME
      REAL*8 DELETE
      COMMON/CLASS/ NROBJ,OBJEC(24)
      COMMON/DELETE/DELETE(24)
      COMMON/ESCALA/EPS,ITER8
C
C    COMMON/KEYLIB/KEYS(LENGTH)
C    LENGTH MUST NOT BE LESS THAN THE BLOCKSIZE OF THE CATALOGED KEYLIB DATASET
      COMMON/KEYLIB/KEYS(3258)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSEC(3,6),DDNAME(10)
      COMMON/TYPES/OBJNME(24)
C    COMMON/WORKIN/SPACE(6*KOMPS*KOMPS+8*KOMPS)
      COMMON/WORKIN/SPACE(680)
C OBJNME=THE ACTUAL OBJECT NAME(S) OF THE TYPE-OBJECT(S) TO BE PROCESSED
C NROBJ=NUMBER OF TYPE-OBJECT(S) TO BE STATISTICALLY PROCESSED
C OBJEC=THE ACTUAL OBJECT-NUMBER(S) OF THE TYPE-OBJECT(S) IN THE TYPE-LIBRARY
      DATA OBJNME/'CLEARC73','CLEARC72','REGROW11','REGROW16','PINE    '
     2/
      DATA NROBJ,OBJEC/5,1,2,3,4,5/
      DATA EPS,ITER8/1.0-08,20/
      DATA DDNAME/'KEYLIB  ','DATASETI'/
      DATA DELETE/'PINE    '/
      END
```

COMMON/WORKIN/SPACE(x) — x must be at least (6*KOMPS*KOMPS+ +8*KOMPS)

DATA OBJNME/'CLEARC73' ,'PINE    '/ — OBJNME(1), ... Names of the type-objects to be processed.

DATA NROBJ,OBJEC/5,1,2,3,4,5/

- NROBJ — Number of type-objects to be processed.
- OBJEC — Actual object-number(s) (increasing values) of the type-objects in the type-library.

OBJNME(1), ... must correspond to OBJEC(1), ... and be in numerical order.

| | |
|---|---|
| DATA EPS,ITER8/1.D-08,20/ | EPS Criterion of interruption.<br>ITER8 Number of iterations in eigenproblem calculations. |
| DATA DELETE/'PINE '/ | If 'PINE ' exists as a type-class in KEYLIB, it will be deleted before any possible further processing is started. |

Subroutines in this task:

INTRAK (INTBYT,KEYTAP(LNDET,BYTINT,ESCALB,FLOBYT,INTBYT,SCALER))

| | | | | | |
|---|---|---|---|---|---|
| TYPE OBJECT: PINE | LINE1 | LINES | LOCUS1 | LOCI | OF MSSBANDS |
| INPUT TYPELIB: N584E122 | | | | | 0 0 0 4 5 0 7 0 0 0 |
| TYPE-OBJECT AREA(S): | 1291 | 4 | 1483 | 4 | 0 0 0 4 5 0 7 0 0 0 |
| | 1297 | 4 | 1453 | 4 | |

INTRACLASS MEAN VECTOR:
4 1.996875E+01
5 1.234375E+01
7 1.584375E+01

INTRACLASS DISPERSION MATRIX (LOWER DIAGONAL PART):

| | 4 | 5 | |
|---|---|---|---|
| 4 | 4.677734E-01 | | |
| 5 | 2.607422E-01 | 9.130859E-01 | |
| 7 | 2.451172E-01 | 1.162109E-01 | 1.464336E+00 |

THE EIGENPROBLEM CALCULATIONS DISCONTINUED AFTER 20 ITERATIONS OR WHEN |F| < 1.0D-08 IN THE SEARCH FOR A ROOT OF THE EIGENFUNCTION F

RIGHT EIGENVECTORS OF THE INTRACLASS DISPERSION MATRIX:
4 2.749230E-01-2.955621E-01-9.149100E-01
5 2.791733E-01-8.860414E-01 3.701254E-01
7 9.200432E-01 3.571744E-01 1.610801E-01

EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
4 1.0000000D+00
5 -1.2272090D-10 1.0000000D+00
7 -2.7810060D-11-6.8751250D-13 1.0000000D+00

EIGENVALUES OF THE INTRACLASS DISPERSION MATRIX:
1.552843E+00 9.532171E-01 3.191359E-01

NATURAL LOGARITHM OF THE DETERMINANT OF THE INTRACLASS DISPERSION MATRIX:
-7.499661E-01

MAXIMUM LIKELIHOOD CLASSIFIER INITIAL TRAINING: EVALUATION OF TYPE-CLASS STATISTICS QUANTITIES FOR THE N584E122 KEY LIBRARY

THE NUMBER OF REPRESENTATIVES EXTRACTED FROM THE SCENE OBJECT TYPIFYING THIS CLASS IS 32

THE N584E122 KEYLIB NOW CONTAINS 5 TYPE-CLASSES WITH A TOTAL OF 140 REPRESENTATIVES

THE N584E122 KEYLIB NOW CONTAINS THE FOLLOWING TYPE-CLASSES
1: CLEARC73
2: CLEARC72
3: REGROW11
4: REGROW16
5: PINE

KROPPEFJÄLL, DALSLAND, CLEAR-CUT INVENTORY (OPHAUG,WASTENSON)

DATE 76-09-14

INTERKEY

Evaluates final interobject statistics quantities to be used for maximum likelihood classification.

```
      BLOCK DATA
C FOR USE WITH FD4355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DSNAME,DDNAME,EPS
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSSB(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/ESCALA/EPS,ITER8
C
C COMMON/KEYLIB/KEYS(LENGTH)
C LENGTH MUST NOT BE LESS THAN THE BLOCKSIZE OF THE CATALOGED KEYLIB DATASET
      COMMON/KEYLIB/KEYS(3258)
C COMMON/WORKIN/SPACE(6*KOMPS*KOMPS+8*KOMPS)
      COMMON/WORKIN/SPACE(680)
      DATA DDNAME/'KEYLIB  '/
      DATA EPS,ITER8/1.D-08,15/
      END
```

| | | |
|---|---|---|
| DATA EPS,ITER8/1.D-08,15/ | EPS | Criterion of interruption |
| | ITER8 | Number of iterations in eigenproblem calculations. |

Subroutines in this task:

INTERK (INTBYT,AVECT,DTOTAL,ESCAL8,MATMUL,OMITRA,SECMOM)

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-14)

MAXIMUM LIKELIHOOD CLASSIFIER FINAL TRAINING: EVALUATION OF INTERCLASS STATISTICS QUANTITIES FOR THE N584E122 KEY LIBRARY

```
INTERCLASS MEAN VECTOR:
 4  2.255713E+01
 5  1.505000E+01
 7  2.029997E+01

INTERCLASS DISPERSION MATRIX (LOWER DIAGONAL PART):
 4  2.975560E+00
 5  2.529457E+00 4.404651E+00
 7  4.247396E+00 1.142282E+00 1.573882E+01
```

THE EIGENPROBLEM CALCULATIONS DISCONTINUED AFTER 15 ITERATIONS OR WHEN |F| < 1.0D-08 IN THE SEARCH FOR A ROOT OF THE EIGENFUNCTION F

```
EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
 4  1.000000D+00
 5 -3.570417D-13 1.000000D+00
 7 -4.828074D-13-3.094996D-12 1.000000D+00

EIGENVALUES OF THE TRANSFORMED OMIT-CLEARC73 DISPERSION MATRIX:
 2.212044E+01 4.771733E+00 1.158403E+00

EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
 4  1.000000D+00
 5 -1.077868D-11 1.000000D+00
 7 -1.387779D-16 1.252823D-11 1.000000D+00

EIGENVALUES OF THE TRANSFORMED OMIT-CLEARC72 DISPERSION MATRIX:
 2.046512E+01 6.578749E+00 5.212763E-01

EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
 4  1.000000D+00
 5  8.759877D-13 1.000000D+00
 7 -4.188924D-14-1.095284D-11 1.000000D+00

EIGENVALUES OF THE TRANSFORMED OMIT-REGROW11 DISPERSION MATRIX:
 2.093047E+01 1.003754E+01 8.905035E-01

EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
 4  1.000000D+00
 5  1.196265D-14 1.000000D+00
 7 -1.124101D-15-1.603162D-13 1.000000D+00

EIGENVALUES OF THE TRANSFORMED OMIT-REGROW16 DISPERSION MATRIX:
 1.068181E+01 2.362064E+00 5.911416E-01

EIGENVECTOR MULTIPLICATION CHECK = UNIT MATRIX (LOWER DIAGONAL PART):
 4  1.000000D+00
 5 -6.582487D-12 1.000000D+00
 7 -4.830336D-11-1.011840D-10 1.000000D+00

EIGENVALUES OF THE TRANSFORMED OMIT-PINE      DISPERSION MATRIX:
 4.440283E+01 9.164378E+00 1.792923E+00
```

THE N584E122 KEYLIB CONTAINS 5 TYPECLASSES WITH APPROPRIATE STATISTICS QUANTITIES EVALUATED AND READY FOR USE IN CLASSIFICATIONS

KROPPEFJÄLL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

TYPESORT

Maximum likelihood classification of a selected window using the statistically preprocessed data of the appropriate KEYLIB.

```
      BLOCK DATA
C    FOR USE WITH FOA355 TELEGNOSTICS SUBROUTINE LIBRARY
C
      REAL*8 DSNAME,DDNAME
      COMMON/TGLIB/DSNAME,LINE1,LINES,LOCUS1,LOCI,MSS3(10)
      COMMON/LAQSAM/KARD(3),LIST(3),LAQSFC(3,6),DDNAME(10)
      COMMON/MAXDEV/BOUND
C
C COMMON/KEYLIB/KEYS(LENGTH)
C LENGTH MUST NOT BE LESS THAN THE BLOCKSIZE OF THE CATALOGED KEYLIB DATASET
      COMMON/KEYLIB/KEYS(3258)
C COMMON/WORKIN/SPACE(6*KOMPS*KOMPS+8*KOMPS)
      COMMON/WORKIN/SPACE(680)
C
      DATA DSNAME/'SORTED  '/
      DATA BOUND/2.0/
      DATA LINE1,LINES,LOCUS1,LOCI,MSS8/1201,128,1444,128,4,5,7/
      DATA DDNAME/'KEYLIB  ','DATASETI','SORTED  '/
      END
```

| | |
|---|---|
| COMMON/WORKIN/SPACE(x) | x must be at least (6*KOMPS*KOMPS+ +8*KOMPS) |
| DATA BOUND/2.0/ | Using 2.0 standard deviations per channel in the classification as acceptance/rejection criterion. |
| DATA LINE1,... | See the description of the source deck. |

Subroutines in this task:
MSSORT (INTBYT,CULLER(TGHEAD,INTBYT,FLOBYT,BYTINT)).

ORIGINAL PAGE IS
OF POOR QUALITY

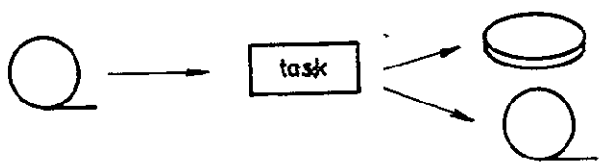
```
488-TYPESORT PAGE  --13

TASK DOCUMENTATION LOG FOR FOA355 MULTILAYER DIGITAL IMAGE DATA HANDLING AND PROCESSING ARCHIVE (76-09-14)

LANDSAT:

SCENE/FRAME ID   EXPOSURE   SCENE CENTER      ORIGINAL   CORIOLISRECTIFIED
 SDDD-HHMMSRN     DATE; JT    LAT    LONG       CCT(S):      LINE LENGTH
 1330-0952300    18JUN73 C N58-41/E012-23     1 2 3 4          3358

INPUT DATASET SUBSCENE:          LINE1      LINES    LOCUS1      LOCI     OF MSSBANDS
      KROPPEFJ                    1073       256       1348       256      4  5  6  7
CLASSIFIED SUBSCENE: SORTED      1201       128       1444       128         ALL  3

MAXIMUM LIKELIHOOD CLASSIFICATION USING THE N584E122 KEY LIBRARY

SORTING INTO  5 CLASSES BUT REJECTING EVERY PIXEL OUTSIDE 2.0 STANDARD DEVIATION(S) PER MSSBAND FROM ITS MAXIMUM LIKELIHOOD CLASS
 0: REJECTS
 1: CLEARC73
 2: CLEARC72
 3: REGROW11
 4: REGROW16
 5: PINE

KROPPEFJÄLL, DALSLAND, CLEAR-CUT INVENTORY (ORHAUG,WASTENSON)

DATE 76-09-14
```

GROUPING IF TASKS BY I/O UNITS


CCTMERGE

REPLIC8

SIXPACK




MERGTAP

CCTAP

CNESTAP


NUANCES

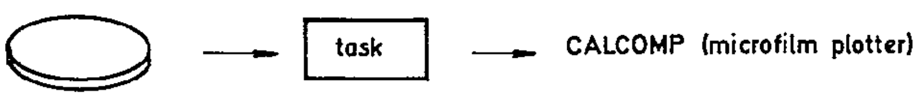
HISTOGR

FOA 355

FOA 356

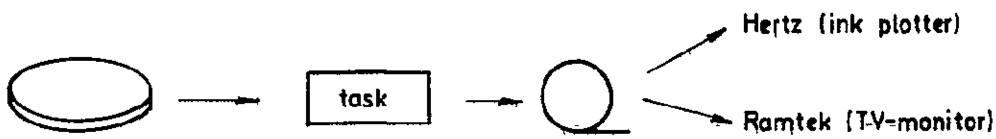
COVCORR

HEXPIXEL




PROJEC2D

CALCOMP




INKJETS

RAMTEK


COMPOUND

MOVE

TYPEHEAD

TYPELIB

KEYHEAD

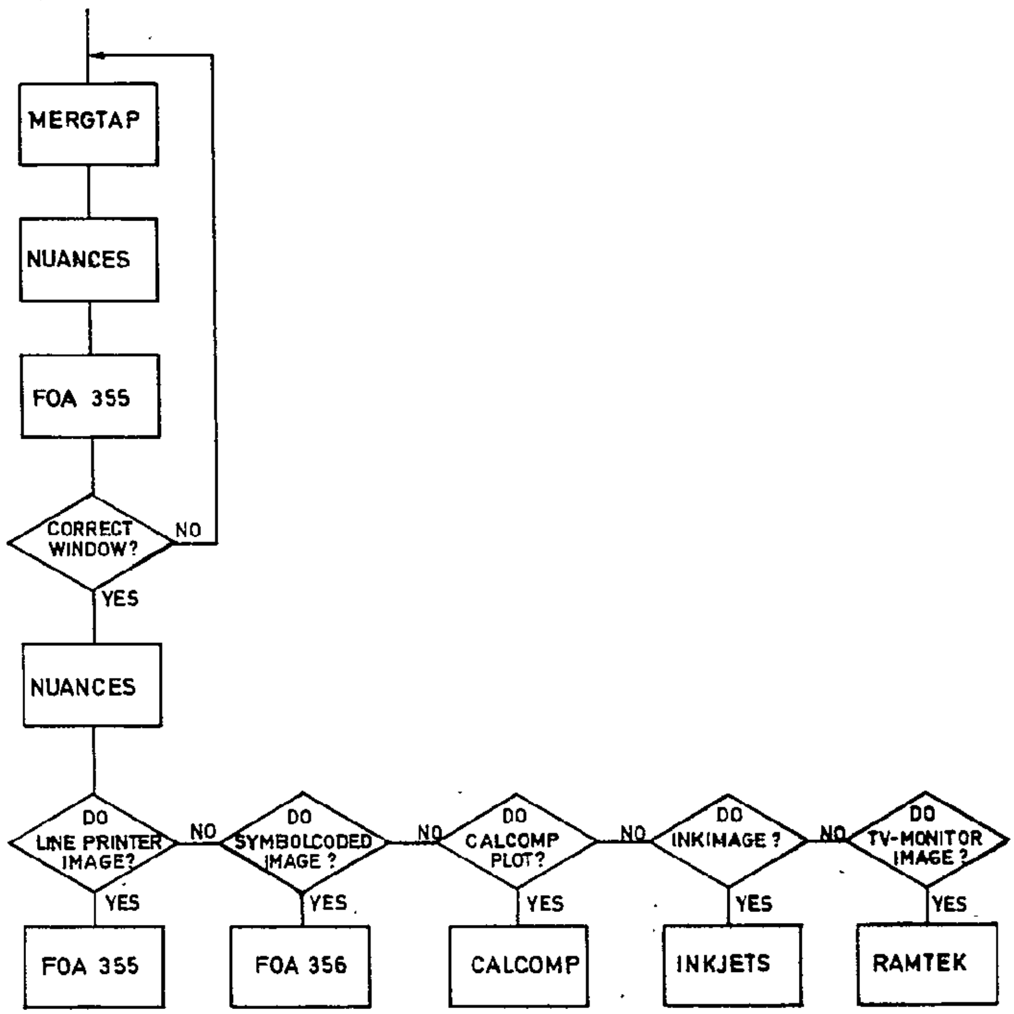
INTRAKEY

INTERKEY

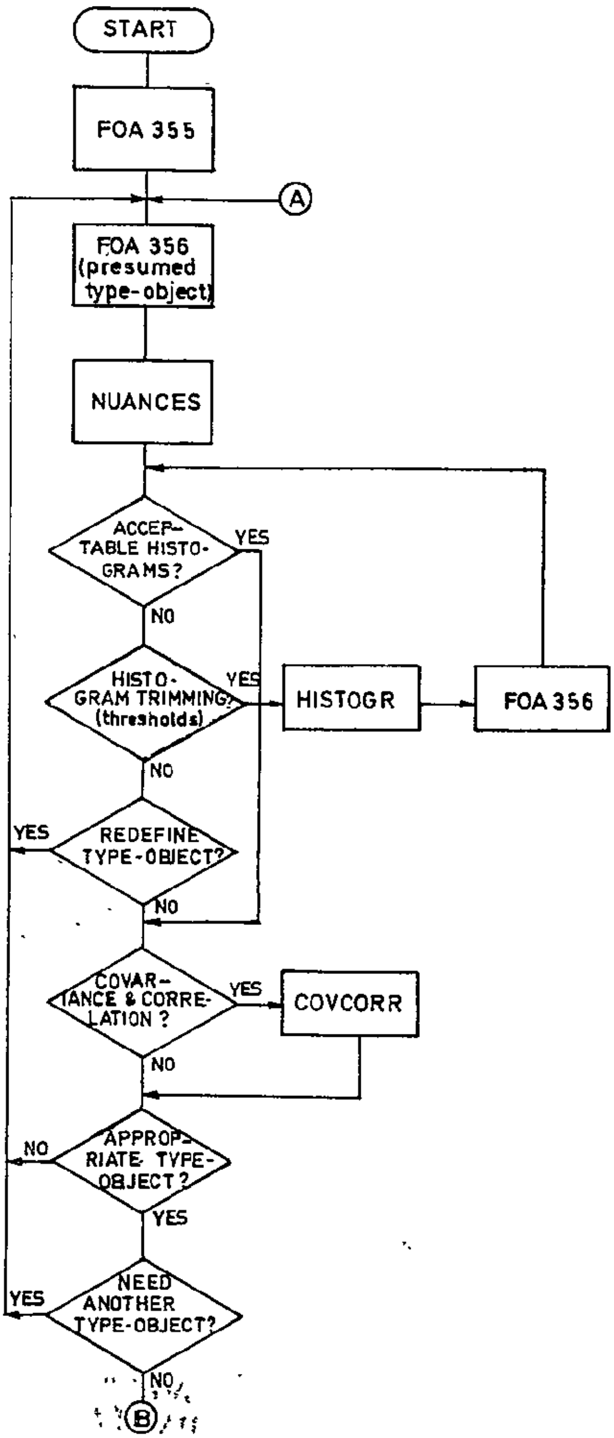
TYPESORT

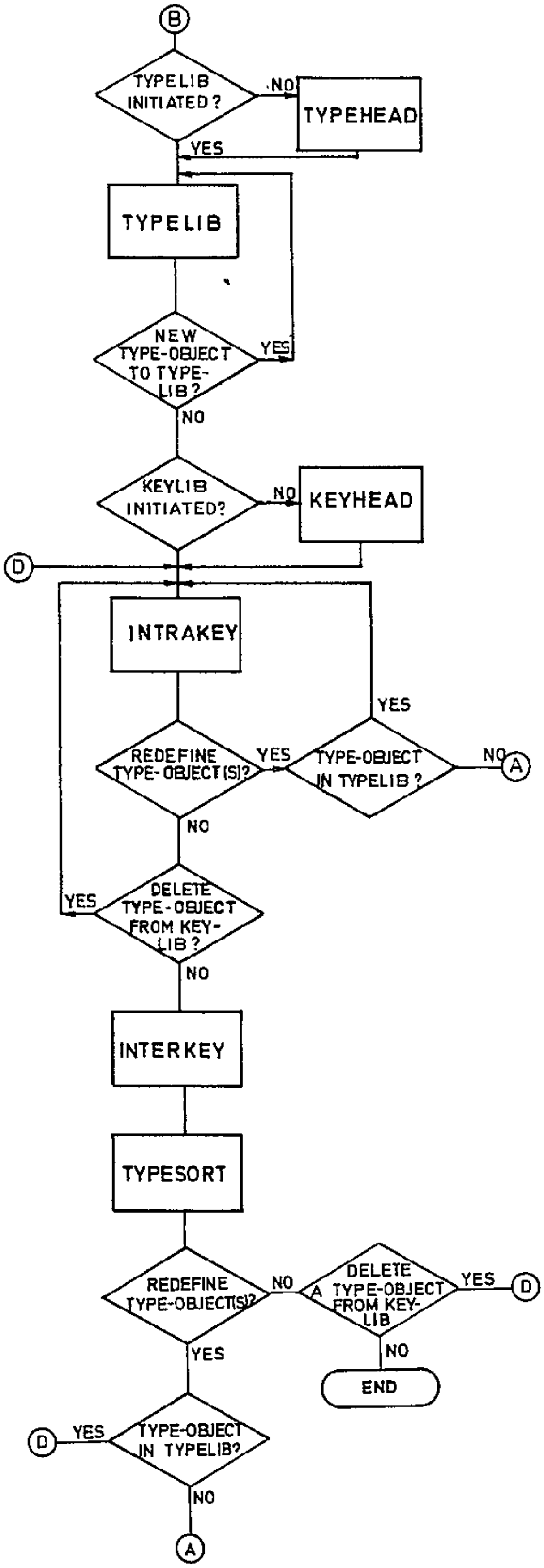
TYPICAL APPLICATION TASKS

IMAGE GENERATION



TRAINING AND CLASSIFICATION




B
TYPELIB INITIATED?
NO
TYPEHEAD
YES
TYPELIB
NEW TYPE-OBJECT TO TYPE-LIB?
YES
NO
KEYLIB INITIATED?
NO
KEYHEAD
D
INTRAKEY
REDEFINE TYPE-OBJECT(S)?
YES
TYPE-OBJECT IN TYPELIB?
YES
NO
A
NO
DELETE TYPE-OBJECT FROM KEY-LIB?
YES
NO
INTERKEY
TYPESORT
REDEFINE TYPE-OBJECT(S)?
NO
A
DELETE TYPE-OBJECT FROM KEY-LIB
YES
D
NO
END
YES
TYPE-OBJECT IN TYPELIB?
YES
D
NO
A