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Hjalmar Thiel

Benthic Investigations of the deep Red Sea

Cruise Reports:

R. V. »Sonne«-Meseda I (1977)
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Untersuchungen zum Tiefsee-Benthos des Roten Meeres Nr. 1

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Contents.

Abstract.

Industrial activities in marine habitats usually involve some risk of environmental pollution. Ecological investigations are an essential component of feasibility studies that attempt both to predict the potential impact and advise on the avoidance of harmful effects. On this basis the "Saudi Sudanese Commission for the Exploitation of the Red Sea Resources" initiated oceanographical studies related to the proposed mining of metalliferous sediments from the central trough of the Red Sea in depths of about 2000 m. Initial ecological investigations were made in 1977 and in 1979. They included a coral reef survey, plankton and nutrient studies, and research on the deep benthos. This report presents the background of the applied studies together with the academic implications of the results. For the benthos studies, detailed information on the work achieved on board R.V.s "Sonne" and "Valdivia" are given including maps, station lists, the depth profile around which sampling and photographing concentrated in 1977, and short gear descriptions.

Zusammenfassung.

Industrielle Aktivitäten im Meer beinhalten meist ein gewisses Risiko für das Meer durch Verschmutzung. Ökologische Untersuchungen sind wesentliche Teile vorbereitender Arbeiten, um die potentiellen Schäden abschätzen zu lernen und Nachteile für Lebensraum und Menschen zu vermeiden. Unter diesen Voraussetzungen hat die "Saudi Sudanese Commission for the Exploitation of the Red Sea Resources" meereskundliche Untersuchungen angeregt und durchführen lassen, die in engem Zusammenhang zum Abbau metallhaltiger Sedimente aus 2000 m Tiefe im Zentralgraben des Roten Meeres ste-

hen. Erste ökologische Arbeiten wurden mit den Rohstoff-Forschungsschiffen "Sonne" (1977) und "Valdivia" (1979) unternommen. Dabei wurden Untersuchungen in einem Korallenriff ausgeführt, Plankton und Nährstoffe im freien Wasser wurden erfaßt und das Tiefsee-Benthos berücksichtigt. Dieser Bericht gibt den Hintergrund der angewandten Fragestellungen und bespricht die allgemeine, biologisch-ozeanographische Bedeutung der erwarteten Forschungsergebnisse, soweit diese das Benthos betreffen. Für die Benthosarbeiten werden Stationslisten und -karten, das Tiefenprofil des Hauptschnittes von 1977 und kurze Beschreibungen der eingesetzten Geräte gegeben.

1. Introduction.

1.1 General aspects.

Over the past thirty years research into the biology of the deep sea has made important contributions in the field of marine science. National deep-sea expeditions, organized in Sweden, Russia and Denmark, have sailed around the world sampling macro- and megafauna throughout the world ocean, including ocean trenches. During the nineteen sixties the United States, Great Britain, France, and the Federal Republic of Germany followed with more localized programmes. With regard to the deep-sea benthos many subjects have been treated; to mention only some of the investigations and publications: macrofauna (SANDERS, HESSLER & HAMPSON 1965, GAGE 1979, LAUBIER & SIBUET 1979), diversity (HESSLER & SANDERS 1967, REX 1973, SANDERS 1969), life history strategies (REX 1979), megafauna (RICE, ALDRED, BILLET & THURSTON 1979), meiofauna (THIEL 1975, DINET 1979), microorganisms (MORITA 1979), zonation (ROWE & MENZIES 1969, GRASSLE, SANDERS & SMITH 1979), biomass distribution (ZENKEVICH et al. 1971, ROWE 1971), community size structure

(THIEL 1975, 1979a), reproduction (ROKOP 1974, 1977; TYLER & GAGE 1979), adaptations (MONNIOT 1979), hadal or ultraabyssal life (BELYAEV 1966, WOLFF 1970, GEORGE & HIGGINS 1979), community respiration (SMITH 1978), and physiology related to high pressure (MACDONALD 1975).

Deep-sea research during the last decades has covered nearly all the oceans, including arctic and antarctic areas, however, one very fascinating locality remained unstudied by modern deep-sea biologists: the deep Red Sea. During the time span of the International Indian Ocean Expedition (1960 - 1965) quite a number of research vessels passed through the Red Sea. Although geological, physical, and chemical investigations were made on the deep water and the bottom, the plankton and benthos were but rarely studied.

In the mid sixties, close cooperation between the scientists of R.V. "Atlantis", R.R.S. "Discovery" and F.S. "Meteor" (DIETRICH & KRAUSE 1969, MILLER 1969, SWALLOW 1969) resulted in the discovery of "hot spots" in the Red Sea, where temperatures up to nearly 60° C and salinities of up to 320 ‰ were measured. The water column, which exhibits normal temperatures and chemical composition of the Red Sea, is sealed off from the underlying metalliferous muds by the hot brines. Closure of the Suez Canal from 1967 to 1976 inhibited further research in the Red Sea, with the exception of visits by R.V. "Wando River" in 1969 and R.V. "Valdivia" in 1971 and 1972 (BÄCKER 1976) passing in from the south. However, interest was focussed on the metalliferous sediments and their mining possibilities, and the benthos was never considered.

Despite this, biologists were aware of the possible ecological implications of these peculiar conditions in this relatively shallow (2000 m deep) deep-sea basin. Tropical blue water generally shows a very low productivity and hence the standing stock of populations in such a deep-sea area should be correspondingly low. Such an assumption is supported by the high temperature of 21.5°C throughout the deep-water column, down to the bottom, suggesting relatively high metabolic rates in an already very sparsely populated sea. Curiously enough, the only sampling of the deep-sea benthos in the Red Sea was undertaken in the years 1895 - 1897 by the Austrian ship "Pola" (see POTT 1898 and 1899 for descriptions of the cruises and BALSS 1915 for the list of 74 dredgings). It was natural that scientific curiosity during those early days of biological deep-sea research was directed towards the study of patterns of vertical distribution of the deep-sea fauna (FUCHS 1901), their morphological adaptations and taxonomy. Those aspects have not lost their pertinence, because such knowledge of the organisms and their distribution allows the delineation of zoogeographical regions and ecological boundaries. During the "John Murray Expedition" on H.E.M.S. "Mabahiss" in 1933/34 a total of 11 samples was taken with grabs, dredges, and trawls in the Red Sea and three of these were from beyond a depth of 500 m (732 - 1167 m). Only one dredge sample from 650 m depth was collected by "Meteor" on passing the Red Sea in 1964. However, virtually nothing has been done on the deep Red Sea in terms of quantitative sampling and evaluation, despite the current interest in faunal densities and metabolic rates.

It was with great fascination that I took the opportunity of undertaking qualitative and quantitative research on the bottom populations living in the deep, warm water of the Red Sea. Comparison with other deep-sea systems, governed by a temperature regime of only 2 - 4°C at the same depth, should help to understand community adaptation to deep-sea conditions. During recent years the International Indian Ocean Expedition and the South African Museum's "Meiring Naude" cruises in 1975 and 1976 (LOUW 1977) added much to the biological collections from the Indian ocean, from which species migrated into the Red Sea. Quantitative data are available only from other oceans. Similarities and dissimilarities will emerge through species and biomass comparison.

Our benthic deep-sea project in the Red Sea constitutes a good example of the close interrelation between basic and applied investigations. This is a significant aspect of biological oceanography today: basic studies and general results are incorporated, soon after their publication, into applied research programmes. Therefore, one should be aware, at the present rate of industrial expansion into the deep sea, of the urgent need for more basic information on the deep biological systems (e.g. HESSLER & JUMARS 1979, RICE 1979).

1.2 The applied aspects.

The present opportunity to study the deep Red Sea was mediated through PREUSSAG AG, Hannover, as main contractor with the "Saudi Sudanese Commission for the Exploitation of the Red Sea Resources" for further exploration and feasibility studies related to the mining of the metalliferous sediments in the Atlantis-II-Deep. An environmental impact study is included in the contract in order to understand the potential influences of all mining activities on the natural resources of the Red Sea. It is the intention of the two countries to exploit the metalliferous muds for their content of iron, nickel, and silver, and probably also cadmium and sulphur. The muds will be pumped up to a processing ship, where a flotation technique will separate the commercially valuable components. About 97 % of the mud, diluted with sea water to 300 % of volume, has to be delivered back into the sea. Processing the muds includes some potential impact on the environment and on the natural economically important resources, i.e. fish and other sea food, coral reefs, aquaculture and pearl farming.

Although little is presently known of the total Red Sea ecosystem, data on the oceanic plankton communities and on the deep benthic populations are particularly sparse. Such investigations therefore are essential for any potential environmental impact evaluation. The environmental program is organized by the "Saudi Sudanese Commission for the Exploitation of the Red Sea Resources" and is achieved with the technical assistance of PREUSSAG AG, and has the aim of gathering basic information on the natural conditions and of elucidating potential impacts for the avoidance of any harmful effect on the natural communities. The programme covers a wide range of oceanographic research in the central Red Sea. It includes: determinations of the hydrographic structures of water masses; measurements of currents; analyses of nutrients; studies on phytoplankton and primary productivity; research on zooplankton distribution and vertical migration; investigations of benthos communities; analyses of heavy metals in fish, benthic species, total plankton samples, water and sediments. In addition to these open water investigations coral reef-communities are studied. Special experiments utilising both the hot brine muds and the tailings will assess harmful concentrations for a variety of organisms (KARBE, THIEL & WEIKERT, in press).

The present paper covers only the report on the benthos investigations. It is the first of a series of contributions reporting on the benthic system of the Red Sea, that will appear preferably in serial publications of the Forschungsinstitut und Natur-Museum Senckenberg under the common heading "Investigations on the Red Sea deep benthos" or "Untersuchungen zum Tiefsee-Benthos des Roten Meeres" (THIEL 1979 b).

2. Oceanographic background.

The Red Sea measures 1932 km in length and its maximum breadth is not more than 300 km. It is a young sea that opened some 25 million years ago as a rift prolonging the East-African graben system (DAVIES 1969, GIRDLER 1969). This narrow oceanic basin is connected to the Mediterranean through the Bitter Lake and the Suez Canal in the north, but there is no water transport into the Red Sea (MORCOS 1970). In the south a sill isolates the Red Sea from the Indian Ocean. This sill has a maximum depth of 100 m, and completely isolates the deep Red Sea water from the deep Indian Ocean water masses, while some water exchange occurs in the upper zone. The hydrographic structure strongly depends on evaporation and on wind-driven inflow of Indian Ocean surface water. In passage north the water loses in temperature, and gains in salinity and density through evaporation. During the cooler winter season the water in the north reaches its highest density and sinks (SIEDLER 1969) renewing the deep water and supplying oxygen to all depths.

Except for the layer immediately in contact with the metalliferous sediments, water temperature is uniformly close to 21.5° C from the thermocline at depths between 100 and 200 m, down to the depths of more than 2000 m. The deep Red Sea basin holds the warmest deep water mass on this planet (Mediterranean deep water is only 13° C). In the Red Sea the oxygen content is about 4.5 ml/l in surface waters and, in the oxygen minimum layer, it drops to 0.5 - 1.5 ml/l in depths of 200 - 400 m. At greater depths 2 - 3 ml/l of oxygen regularly are found. It may be assumed that oxygen supply and oxygen demand must, on the average, be equal at all depths in order to maintain these levels over long periods.

Like temperature and oxygen, salinity remains rather constant with depth. Current measurements are rare and somewhat contradictory. Since the main transport of water at the surface is directed to the north, the deep water should compensate with a southerly movement. However, only part of the total water mass must be involved in such a compensatory current, and water transport into different directions may occur. Current speeds should be rather slow throughout.

Because of the high temperature in the deep Red Sea and a generally low standing stock and rate of production of plankton and nekton in surface waters (HALIM 1969), the deep-sea benthos may be predicted to have a low standing stock, a high species diversity, and a composition of predominantly small individuals. These topics will be considered in later publications.

3. The sampling scheme.

R.V. "Sonne", a converted stern trawler of 3865 t, was available for cruise MESEDA I (Metalliferous Sediments, Atlantis-II-Deep) in 1977, while R.V. "Valdivia", as well a former stern trawler of 2115 t, was chartered in 1979 for MESEDA II.

It was planned to concentrate benthos investigations for MESEDA I on a transect along the deep terrace and down into the central graben near the Atlantis-II-Deep (fig. 1)*. In most of this area, the depth gradient, according to the available charts, would not be steep enough to pose difficulties during sampling. The transect

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* The charts presented in figure 1 and figure 3 are compiled from various sources. The depth contours for 1000, 1500 and 2000 m are taken from PREUSSAG profilings.

For the depth lines of ~200 m (100 fathoms) and 550 m (300 fathoms) a chart of A.S. LAUGHTON, Institute of Oceanographic Sciences, Great Britain, was used. Uncertainities of these contours become evident from the powas positioned in 21°15'N and the depth gradient was profiled in preparation for sampling (profile Ex 35, fig. 2). The steep reef-near slope drops off to 700 m and falls further to 800 m with a subsequent depth decrease to 700 m. Depth increases slowly to 800 m, and in an irregular manner down to about 850 m in a distance of 67 km from the reef-near slope. The central graben slope irregularly drops off from 850 m to more than 1900 m within a distance of 22 km.

The benthos stations worked during MESEDA I are shown in fig. 1. Their approximate position in relation to the depth profile is shown in fig. 2. It was not possible to concentrate all the stations along the profile Ex 35 because:

a. depth gradients were too steep and topography too rough, especially for the trawl and the photosled (stations 55, 56, and 58, 59 about 10 nm south of Ex 35, stations 66 - 68 about 12 nm north of Ex 35);
b. sampling close to the Atlantis-II-Deep (stations 50, 51, 61, 90, 96, 108, 4 - 12 nm north of Ex 35);
c. logistic considerations in connection with service obligations for the parallel ongoing Reef Survey I and navigational problems precluded sampling effort (stations 20, 33 - 35 and 42 about 20 nm south of Ex 35 off Shab Baraja Reef).

In 1979 research was concentrated within the frame of the Pre-Pilot-Mining-Test, in the area of the Atlantis-II-Deep (fig. 3). The mining-ship SEDCO 445 conducted initial mining tests. R.V. "Valdivia" accompanied the

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sition of the stations near the slope between the reefs and the deep terrace (fig. 1), which fall into areas too shallow for their positions, determined during "Sonne" cruise 02. These depth lines were included into the charts to demonstrate the steep reef-near slope and the wide deep terrace.

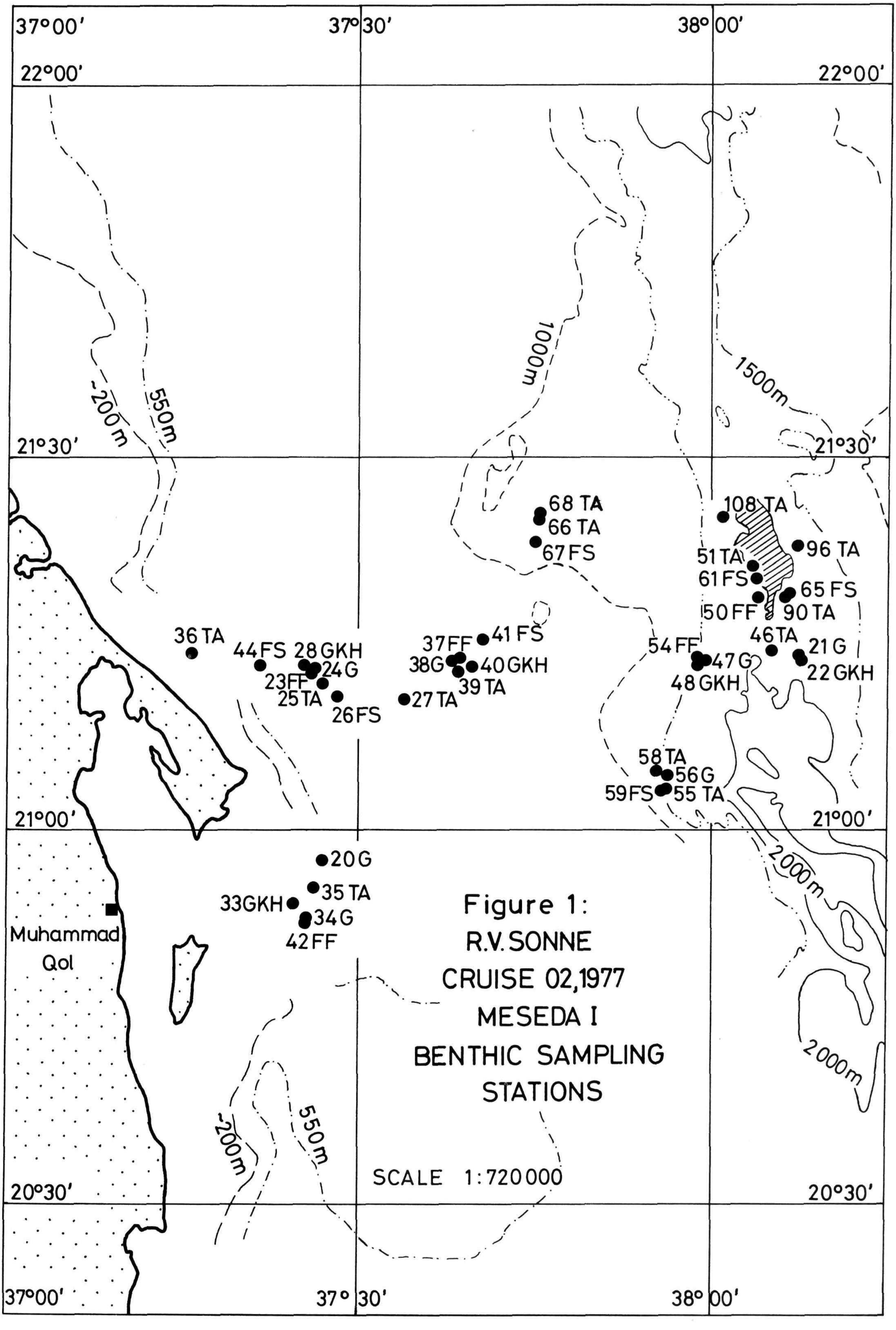

Figure 1: R.V. SONNE CRUISE 02, 1977 MESEDA I BENTHIC SAMPLING STATIONS

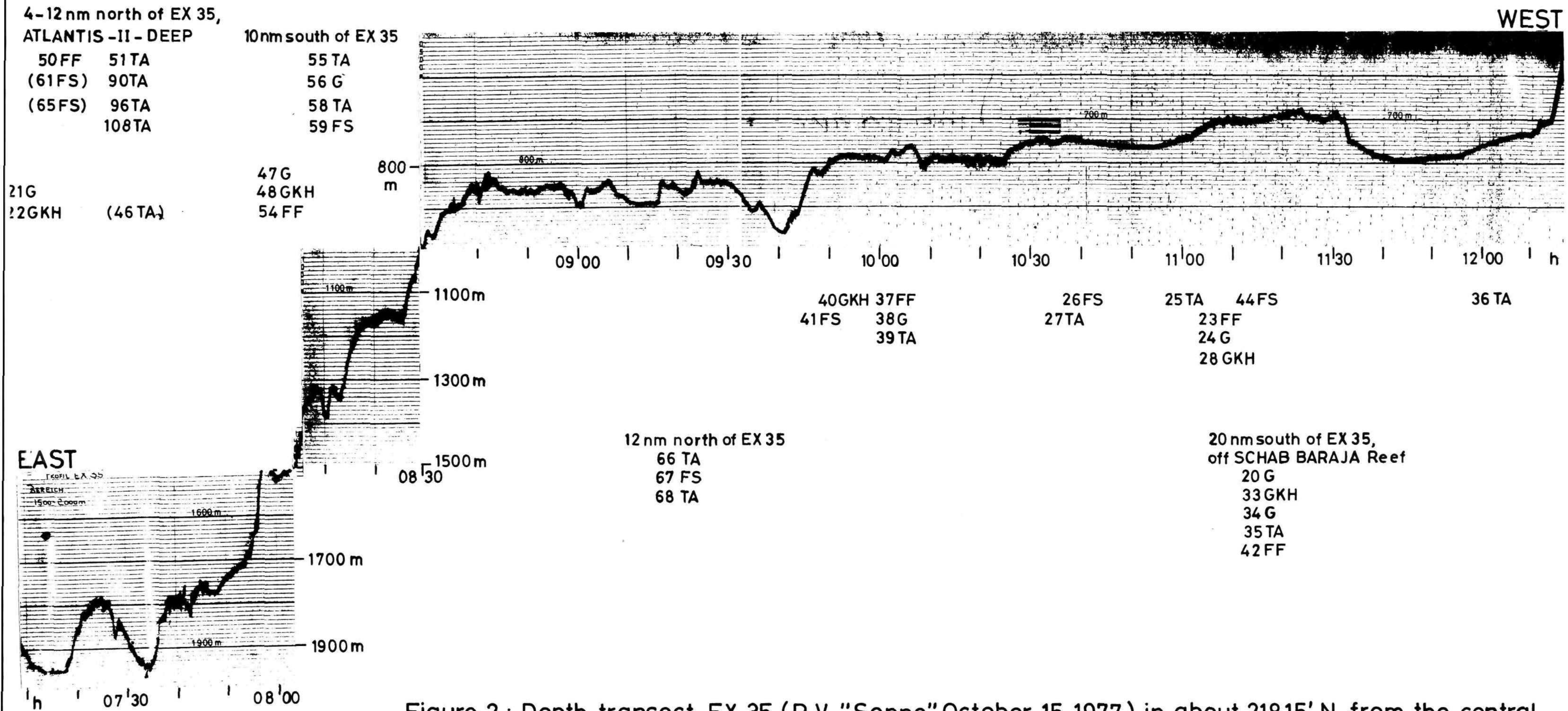

Figure 2: Depth transect EX 35 (R.V. "Sonne", October 15, 1977) in about 21° 15' N from the central graben to the reef near slope. The approximate area of benthic stations is indicated. (sounding profile provided by PREUSSAG, Hannover)

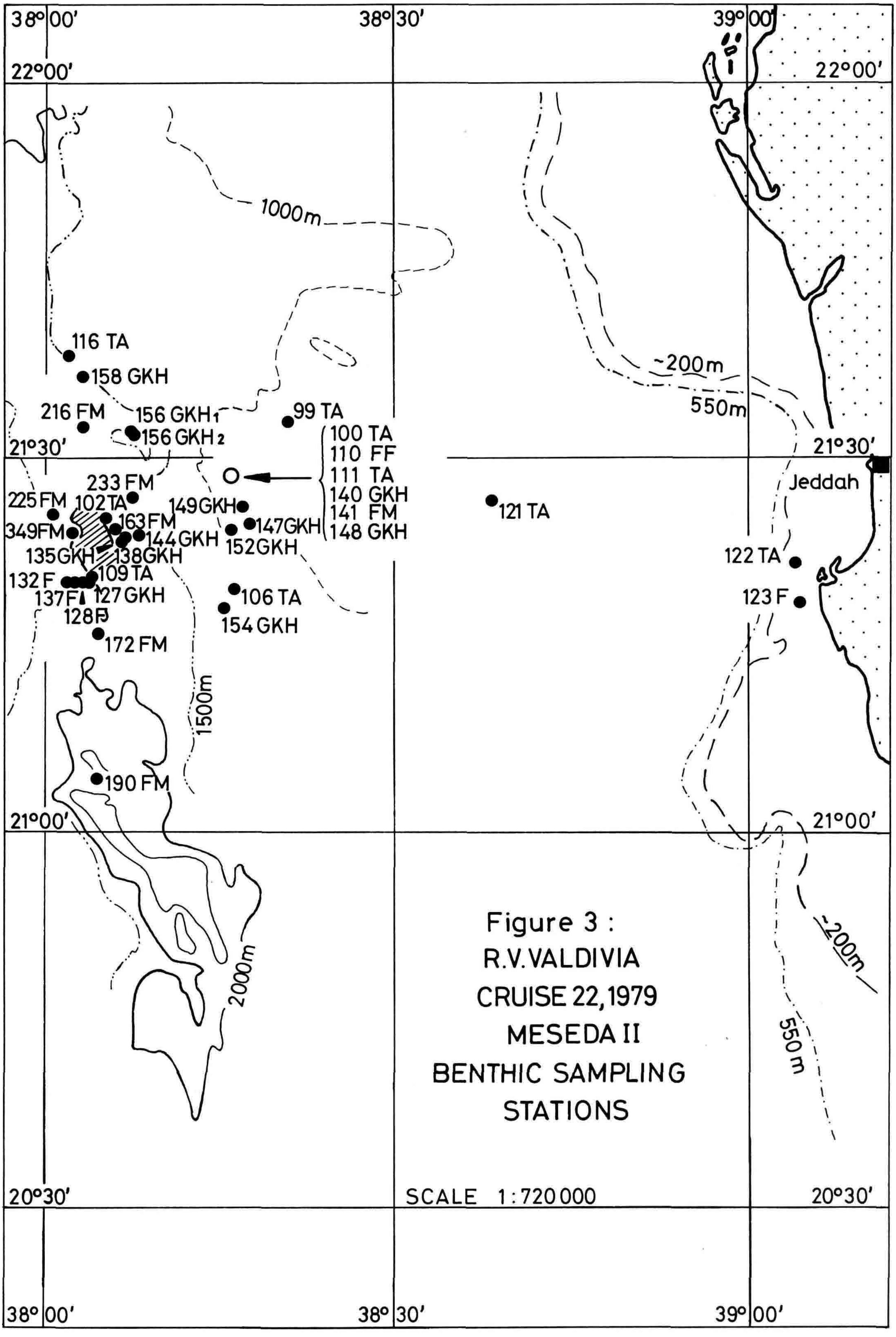

Figure 3 :
R.V. VALDIVIA
CRUISE 22, 1979
MESEDA II
BENTHIC SAMPLING
STATIONS

mining-ship to render assistance and to accomplish research. Sampling and photography were therefore mostly undertaken around the Atlantis-II-Deep. Investigations were also performed along the ship's track and sampling the reef-near slope was begun south of Jeddah in the reef-locked Mismaris Trough. The depth was profiled on May 2nd, 1979, between Jeddah and the Atlantis-II-Deep. Depth drops off from about 200 - 600 m within 1.5 km and falls further down to 700 m in 2 km distance. For the following 48 km depth remains around 700 m with a minimum of 635 m and a maximum of 800 m and slowly increases to 1100 m for a distance of 62 km. The central graben slope down to about 2100 m covers 14 km^2.

Samples of animals and sediments, and the photographs so far obtained, suggest a rather uniform environment and a gradual change in community structure with depth. This allows us to view all the information collected as if it were taken from one biocoenosis, or from one general area. The stations worked off Shab Baraja Reef (MESEDA I) connect our research closely with that of Reef Survey I (KARBE in prep.).

The two expeditions are marked by SO-02 for "Sonne" cruise 02 and VA 22 for "Valdivia" cruise 22. Consecutive numerals were ascribed as station numbers to each gear lowering, and in the log this is followed by letters used as acronyms for the gears employed. Hence, no station number appears twice, but several consecutive station numbers, eventually slightly separated by some ship's drift, may be assigned to the same location. The station lists for MESEDA I and II are presented in tables 1 and 2 respectively, together with gear acronyms.

4. The gear.

During the preparations for the first cruise it became apparent that wire time would become a limiting factor on all the cruise legs. Since we were well aware of the fact that several small bottom samples statistically give a better estimate of quantitative parameters of bottom communities and their structure than one larger sample, it was decided to use two different types of large-area grabs.

4.1 The box grab (GKH).

A large volume box grab was used as described by HESSLER & JUMARS (1974) as the USNEL-Spade Corer. The box covers an inner area of 50 x 50 cm and has a height of 60 cm. Our grab was of the same design and was manufactured by the same company, OCEANIC INSTRUMENTS, at San Diego, California, but it was improved by two modifications. The original grab was provided with two vents on the sides above the sample box. The heavy metal vent plates were hinged open so as to close on return of the grab to the surface. The projecting edges of the vent lids were held open by water pressure during lowering. This design forced the water passing through the box to change its direction, and the heavy lids did not allow the water to pass through freely enough, thus creating a pressure wave in front of the grab, as was demonstrated by JUMARS (1975) by the distribution of polychaetes between subcores.

It seems that all vent-like constructions opened and closed by water resistancy during lowering and heaving fail in effective opening or closing of the box. Therefore, the top cover of the box frame was opened up and stable lids were designed for the present investigations (fig. 5). This allowed a vented area of about 52 % of the total and a good flow straight through the box while lowering the grab. Hence, the greatly reduced bow-wave resulted in the prevention of the light surface sediment being blown away. The vent lids were each made from one rubber sheet with two metal strengthening bars on top of it. In the open position the lids were folded back, standing up on each side of the column during lowering (fig. 5). The lids were loosely tied to the frame of the grab. After the gear comes to rest on the sea bed and the box is pressed into the sediment, the relative movement of box and column compared to the frame triggered the lids for closure.

The second modification aimed at simplifying closure of the box after retrieving the grab. In the original box grab models the lid had to be pushed between the box and the spade plate after recovering the box corer. This is a difficult job for the 50 x 50 cm box, and the sediment surface may be destroyed during this operation. The spade of the grab was modified so as to carry a box lid as its spade plate. In this way the box lid was swung into position by closure of the spade while on the bottom. Back on the ship the box lid had to be loosened from its support and then connected to the box before the spade lever was turned back into the open position.

4.2 Subsampling the box grab.

Inside the box are 25 square tubes, each with an internal section of 9.5 x 9.5 cm, covering, however, an area of 10 x 10 cm because of wall thickness and related sediment compression, were regularly arranged (JUMARS 1975) and held in position by five bars, each running through the top of five tubes. The tubes, at both ends a little shorter than the box, cut the sediment sample into 25 cores of equal size and the surface of the sediment is well protected from strong washing by the water above the sample. The total sample was divided into a number of subsamples generally following the same scheme (fig. 4). During MESEDA II a box without this subdivision was used for better sediment penetration and easier subsampling.

4.2.1 Macrofauna.

During MESEDA I three rows consisting of each five tubes were separately handled as three parallel subsamples, dug out to a sediment depth of 10 cm (fig. 4).

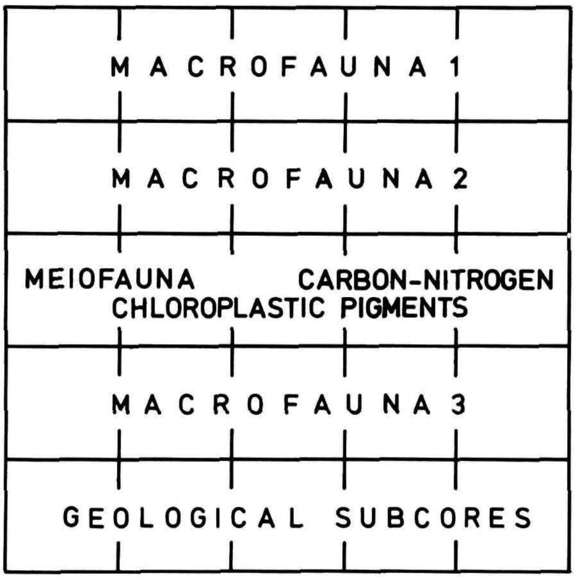

Figure 4:
The subsampling scheme for the vegematic box.

The samples were washed through sieves of 0.5 and 1mm mesh sizes and preserved in hexamethylentetramin buffered 4 %-formalin. In MESEDA II the total area of 2500 cm^2 was used less some small subsamples.

4.2.2 Meiofauna.

In 1977 one syringe of 3.8 cm^2 cross section was extracted from each of the five middle tubes (fig. 4).
The syringe core was adjusted to a length of 5 cm (or 4 cm

in case it was too short) and cut into one-cm-layers, which were completely, but separately, preserved as for the macrofauna. During the second cruise the five subsamples were randomly distributed over the total area, but because of the low standing stock encountered in the earlier samples, only the uppermost 3 cm were preserved.

4.2.3. Chloroplastic pigment equivalents.

Subsampling was performed in the same manner and from the same tubes (fig. 4) as described for the meiofauna. Each layer of a subsample was given into a preweighed centrifuge tube. These had been pre-filled with magnesium carbonate for pH adjustment and some glass-spheres for pigment-cell grinding, for later laboratory processing. The samples were freeze-dried for storage. In 1979 only 2 cm were preserved as one unit.

4.2.4. Carbon and nitrogen.

For analysis of carbon and nitrogen five subsamples were taken as syringe-cores, together with those removed for meiofauna and pigment analysis. The one-cm layers were freeze-dried in small jars.

4.3 The maxi VAN VEEN grab (G).

This grab (fig. 6) was used as a compromise between total bottom area required and wire time. If insufficient time was available to take at least three samples from the same locality, the sample area should be as large as possible, especially where population densities are as low as those expected in the deep Red Sea. This grab was constructed by PREUSSAG AG to sample large volumes of the metalliferous sediments. The grab sampled an area of 1.7 x 1.3 m = 2.2 m^2 and recovers a volume of up to 2 m^3

of sediment. The sediment surface could be seen through a lid on top of the grab to be retained usually in good condition. On only one occasion was the mud so soft that the surface was intermixed with deeper layers. From samples with good surfaces an area was cut out to 10 cm depth as far as one could reach laterally. This area amounted to about half a meter square. The samples were washed using the 1 mm sieve and preservation was done as described above.

4.4 The closing trawl (TA).

The opening and closing epibenthic sledge described by ALDRED, THURSTON, RICE & MORLEY (1976) was used as a model for the construction of our closing trawl (fig. 7). The following description concentrates on the modifications which concern mainly the size of the frame, which needed to pass easily through the heck doors of our research ships. The rectangular frame has an inner width of 3.0 m between the skids. The skids themselves are 0.3 m wide, resulting in a total frame width of 3.6 m. The height of the frame is 1 m, giving a fishing area of 3 m^2. The two side frames are only connected at their tops, but not at the hind bottom corners, as was the case in the type model. Stability is thus achieved by use of stronger materials. In our net it is the bottom rope of the net that cuts through the sediment, and a loose chain is rigged in front of the net to act as a "tickler" chain in order to disturb the bottom.

The closing mechanism is made from a net, hanging down from the hind bar, connecting the side frames. A thinner bar at the lower side of the closing net connects two right angled levers, which can turn at their central point. When the net is lowered to the bottom, or returned to the ship, the closing net is supposed to hang down obstruding the net opening; one arm of each lever running parallel to the skids and the other projecting down from the skids by gravity and assisted by heavy springs. When the frame touches the bottom the lever is turned through 90°, the previously projecting arms being forced back run in line with the skids by the sediment, while the other arms project upwards, maintaining the net open with the closing net rotated upwards as a sort of roof.

The net itself covers a length of 7.4 m, with a stretched mesh width of 30 mm for the front 2.4 m, 20 mm in the mid 3.3 m, and 0.8 mm in the 1.7 m long cod end. The latter is covered with a strong, protective material having a stretched mesh width of 80 mm.

The trawl is towed by means of bridles from the two upper front edges. A weak link, consisting of 50 cm of 8 mm wire, connects the bridles to the ship's deep-sea wire. A security wire runs from the deep-sea wire to the upper hind edge of the frame. This safety link has been of great value on the rough bottom of the Red Sea. On three occasions the net was recovered upside down, rescued by the security wire.

A pinger was fixed to the deep-sea wire 100 m from the net. When the pinger and the bottom indication showed a distance of 40 - 50 m the frame was believed to be running along the bottom correctly, and good catches confirmed this assumption.

4.5 The photosled (FS).

The photosled was originally described by THIEL (1970), and improvements are given in TÜRKAY & THIEL (1977). As with the closing net, a pinger system, a weak link and a safety wire were employed. However, in practice, the weak link never broke, although during two deployments the photosled came fast. On both these occasions the photosled was deployed near the Atlantis-II-Deep in depths of 1900 - 2000 m. On the first occasion after having successfully fished the Wando-Terrace for 1 hour with the closing net, the photosled was lowered and apparently came fast on a rock. In the second lowering we aimed at a transect from the southeast into the Atlantis-II-Deep and this time the sled sank into the mud. It was retrieved in both instances without damage by careful ship manoeuvring and winch and tension-meter control. However, the photographs show mud clouds only.

4.6 The drift camera (F).

Because of the unsuccessful deployment of the photosled near to the Atlantis-II-Deep in 1977, a camera rag was constructed, which carried the equipment of the photosled and a pinger with a bottom contact switch. In 1979 it was tried to drift with limited ship's manoeuvring from about 1500 m depth down to about 2000 m and into the hot brines, however, without much success.

4.7 The phototrap (FF).

Monster camera studies (ISAACS 1969, ISAACS & SCHWARTZLOSE 1975, DAYTON & HESSLER 1972, HESSLER 1974, HESSLER, INGRAM, YAYANOS & BURNETT 1978) demonstrated that some deep-sea invertebrates and fishes are attracted to bait. However, in 1886, and during the following years of his research, Prince ALBERT OF MONACO employed large baited traps in shallow and in deep water (RICHARD 1934). These two methods have been combined by French scientists (GUENNEGAN & RANNOU 1979) and trapping was used by others in the deep sea (PAUL 1973, SCHULENBURGER & HESSLER 1974, HESSLER et al. 1978, THURSTON 1979).

The application of a phototrap had to be done in our Red Sea project, because of the lack of certainity in obtaining successful trawl hauls and because of the photosled encountering stretches of rough bottom, and because of the possibility of obtaining information on larger organisms, not caught with the trawl or documented with the photosled. The trap (fig. 8) had to be constructed as a strong frame in order to carry the camera, flash light and batteries from the photosled, each of them packed into heavy deep-sea housings. The frame was welded using U-shaped steel bars. The bottom length of the trap measures 2.4 m and the bottom width 1.8 m. The sides are trapezoid, 1.9 m high and 1.0 m wide at the top. Only one bar connects the middle of the top sides. At the four corners footplates prevent the trap from sinking into the mud. One of the trapezoid sides carries one support for each the spherical camera housing and the tubelike flash housing. The battery housing is mounted on the opposite side in order to balance weight.

Within this frame an inner net was mounted enclosing the camera and flash housings. The net was made of nylon material having stretched meshes of 2 cm. Two cone-like entrances were braided into the trapezoid sides so that both inner openings were seen by the camera.

The bait was fish, which was hung up or laid on the net bottom. According to the time interval between exposures (20 or 60 sec.), the trap could be deployed for either nearly 9, or 27 hours, shooting up to 1600 frames. The deployment time on the bottom was chosen to fit in with the time schedule of other parts of the programme.

During the course of the MESEDA I expedition the trap construction showed certain shortcomings. Stretching of the net within its frame, and especially around the two entrances was not good. Having realized that shrimps with very long and wide bending antennae entered the trap, it seemed to be necessary to have the entrances wider than necessary for fish. This was achieved by bending some strong plastic grating material into short tubes stretching the entrances. In addition, the net allowed organisms to approach to the bait from below the trap. Finally, the battery housing was mounted in the frame opposite to the camera, precluding a far-distance view outside the net in the center of the photograph. As a result of this experience the trap was modified for MESEDA II.

The length of wire used to lower the trap to the bottom was adjusted according to water depth. A length of wire 10 - 20 % more than the depth was chosen and the end of the wire was fastened to a surface buoy, marked with a flag and a flashing light.

4.8 The medium traps (FM).

Successful results achieved with the phototrap during MESEDA I encouraged further trials on the second cruise using medium traps. As a trap body a black PVC tube was chosen having a length of 120 cm and a width of 60 cm. Two conelike nets with 5 mm mesh size were mounted into the open sides leaving an open entrance of 10 - 12 cm diameter. One net cone was easily removed by opening a screw clamp for the removal of the trapped animals. While these traps caught species of crustaceans and some fish successfully, some of them were squeezed and damaged, as a consequence of the net cone touching the trap body under the influence of water pressure during trap retrieval and through wave action in surface waters.

Several traps were lowered to the sea bed at the same time. They were connected to a wire and this was hooked to a surface buoy.

4.9 The small traps.

As a result of their construction, small animals could not be caught by the photo- and the medium traps and therefore, small traps were made from 1.5 l plastic bottles having a narrow opening. The conical top and the bottom were cut off. While the bottom was sealed with 300 µm plankton gauze, the top was fixed to the bottle in turned position. Hence these small traps were short tubes, which allowed the bait smell to disperse with the currents, and which had a cone-like entrance. Six of these simple constructions were tied to the net of the phototrap, and gave good results.

5. Benthos group: participants and institutions.

MESEDA I: "Sonne" 02, 1977

HJALMAR THIEL	1	Chief scientist
MICHAEL TÜRKAY	2	
DINAR H. NASR	3	
HASSAN H. BASHER	4 & 3	
ROLAND THEEG	1	

MESEDA II: "Valdivia" 22, 1979

HJALMAR THIEL	1
OLAF PFANNKUCHE	1
HANS-JOACHIM WEICHERT	1
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6. Future investigations.

Benthos sampling and photography achieved during MESEDA I and MESEDA II was limited by time and by topographical conditions. The number of samples collected so far, the area from which these were taken and from which bottom photographs are available, is all small in relation to the large area and to the importance of the applied questions that are addressed. Further investigations are essential for the evaluation of the potential environmental impact through mining activities.

These benthos investigations should cover:

1. additional sampling of the central Red Sea, including measurements of biological activity like the respiratory electron transport for total communities.

2. sampling and evaluation of near shore slope sites between the coral reefs and the deep terrace in 500 - 700 m. The steep depth gradient and the rough bottom suggest navigational and sampling problems. A close-up inspection by research submersible therefore would be recommended for safety and financial reasons.

3. investigations of the biological system in the southern and the northern part of the Red Sea, where ecological conditions are different. The evaluation of the results from around the Atlantis-II-Deep would benefit from such comparison.

4. studies on the epifauna from rocky substrates, which are to be expected to occur along the coastal slope and on the slope of the central graben. Hydrothermal vents, and concentrations of large animals associated with them, may be present.

At the time of completing this report MESEDA III is planned and scheduled for autumn 1980, and some of the questions listed will be considered.

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Table 1 cont.

Date 1977	Station-number	Gear	Serial number	Depth (m)	Position	
18.10.	40	GKH	KG 778	831	21°13.50'N	37°39.60'E
18.10.	41	FS	FS 46	980-949	21°15.45'	37°41.25'
18.10.	42	FF	FF 3	456	20°52.35'	37°25.30'
19.10.	44	FS	FS 47	744-703	21°13.10'	37°21.30'
20.10.	46	TA	ST 208	1830-1899	21°14.80'	38°05.10'
20.10.	47	G	BG 779	1723	21°13.68'	37°59.30'
20.10.	48	GKH	KG 780	1549	21°13.40'	37°59.02'
20.10.	50	FF	FF 4	1869	21°18.61'	38°03.82'
21.10.	51	TA	ST 210	1977-1995	21°21.05'	38°03.15'
21.10.	54	FF	FF 5	1544	21°13.90'	37°58.68'
21.10.	55	TA	ST 211	1554-1435	21°03.30'	37°55.90'
22.10.	56	G	BG 781	1471	21°04.30'	37°56.00'
22.10.	58	TA	ST 213	1424-1310	21°04.70'	37°55.40'
22.10.	59	FS	FS 48	1591-1341	21°03.20'	37°56.00'
23.10.	61	FS	FS 49	1966-1935	21°20.31'	38°03.20'
23.10.	65	FS	FS 50	1862-1945	21°19.26'	38°06.89'
23.10.	66	TA	ST 214	1135-1043	21°25.20'	37°45.20'
23.10.	67	FS	FS 51	1135-1083	21°23.50'	37°45.00'
24.10.	68	TA	ST 215	1051-1134	21°25.80'	37°45.20'
02.11.	90	TA	ST 216	1924-1992	21°18.90'	38°06.15'
03.11.	96	TA	ST 217	1778-1752	21°23.18'	38°06.84'
05.11.	108	TA	ST 218	1650-1663	21°25.35'	38°01.05'
17.12.	392	TA	ST 219	1800-1960	21°15.50'	38°06.56'

Table 1: "Sonne" 02, list of benthic stations

Abbreviations:

G VAN VEEN grab, large area (2.2 m^2); GKH Box grab, large area (0.25 m^2);

TA Trawl with closing mechanism; FS Photosled; FF Phototrap.

Date 1977	Station-number	Gear	Serial number	Depth (m)	Position	
13.10.	20	G	BG 770	601	20°57.10'N	37°26.90' E
15.10.	21	G	BG 771	1977	21°14.30'	38°07.20'
15.10.	22	GKH	KG 772	1977	21°14.20'	38°07.30'
15.10.	23	FF	FF 1	731	21°13.00'	37°25.80'
15.10.	24	G	BG 773	740	21°13.20'	37°26.00'
15.10.	25	TA	ST 201	747-724	21°12.00'	37°26.80'
16.10.	26	FS	FS 45	713-733	21°11.10'	37°28.30'
16.10.	27	TA	ST 202	757-733	21°10.80'	37°34.00'
16.10.	28	GKH	KG 774	733	21°13.10'	37°25.60'
16.10.	33	GKH	KG 775	507	20°53.70'	37°24.48'
17.10.	34	G	BG 776	487	20°52.30'	37°25.10'
17.10.	35	TA	ST 203	588-490	20°54.90'	37°26.10'
17.10.	36	TA	ST 204	823-824	21°14.45'	37°15.90'
17.10.	37	FF	FF 2	831	21°14.00'	37°38.50'
17.10.	38	G	BG 777	836	21°13.80'	37°38.00'
17.10.	39	TA	ST 205	780-800	21°12.80'	37°38.50'

Table 2: "Valdivia" 22, list of benthic stations

Abbreviations:

GKH Box grab, large area (0.25 m^2); TA Trawl with closing mechanism;

FM Chain of medium traps; FF Phototrap; F Drift camera.

Date 1979	Station-number	Gear	Serial number	Depth (m)	Position	
09.04.	99	TA	ST 230	804 - 753	21°33.00'N	38°21.00'E
09.04.	100	TA	ST 231	969 -1110	21°28.87'	38°15.37'
10.04.	102	TA	ST 232	1852-1907	21°25.06'	38°05.21'
11.04.	106	TA	ST 233	1085-1121	21°19.00'	38°15.90'
12.04.	109	TA	ST 234	1955-1987	21°20.32'	38°03.27'
12.04.	110	FF	FF 6	740	21°28.97'	38°15.55'
12.04.	111	TA	ST 235	740 - 785	21°28.97'	38°15.55'
14.04.	116	TA	ST 236	1469-1437	21°38.20'	38°02.00'
15.04.	121	TA	ST 237	801 - 779	21°26.50'	38°38.30'
17.04.	122	TA	ST 238	383 - 363	21°22.00'	39°04.00'
17.04.	123	F	FD 1	381 - 385	21°18.85'	39°04.32'
18.04.	127	GKH	KG 785	1965	21°20.16'	38°03.19'
19.04.	128	F	FD 2	2006	21°20.21'	38°03.16'
19.04.	132	F	FD 3	1548-1673	21°20.18'	38°02.01'
20.04.	135	GKH	KG 786	1855	21°23.55'	38°06.75'
20.04.	137	F	FD 4	1680-1740	21°19.93'	38°02.19'
21.04.	138	GKH	KG 787	1905	21°23.95'	38°06.44'

Table 2 cont.

Date 1979	Station-number	Gear	Serial number	Depth (m)	Position	
21.04.	140	GKH	KG 788	735	21°28.70'N	38°15.30'E
21.04.	141	FM	KF 1	748	21°28.70'	38°15.30'
22.04.	144	GKH	KG 789	1912	21°23.95'	38°07.52'
22.04.	147	GKH	KG 790	980	21°24.90'	38°17.20'
23.04.	148	GKH	KG 791	763	21°28.80'	38°15.40'
23.04.	149	GKH	KG 792	1051	21°26.20'	38°16.20'
24.04.	152	GKH	KG 793	1095	21°24.40'	38°15.60'
24.04.	154	GKH	KG 794	1220	21°17.80'	38°15.00'
25.04.	156	GKH-1	KG 795	1517	21°32.00'	38°07.20'
25.04.	156	GKH-2	KG 796	1528	21°31.80'	38°07.30'
26.04.	158	GKH	KG 797	1505	21°36.50'	38°03.20'
27.04.	163	FM	KF 2	1850	21°24.47'	38°05.95'
04.05.	172	FM	KF 3	1935	21°23.20'	38°04.64'
07.05.	190	FM	KF 4	2210	21°04.00'	38°04.20'
16.05.	216	FM	KF 5	1594	21°32.50'	38°03.20'
19.05.	225	FM	KF 6	1852	21°25.05'	38°00.45'
21.05.	233	FM	KF 7	1390	21°26.90'	38°07.73'
15.06.	349	FM	KF 8	1881	21°24.20'	38°02.19'
20.06.	366	FM	KF 9	1221	24°43.36'	36°14.44'

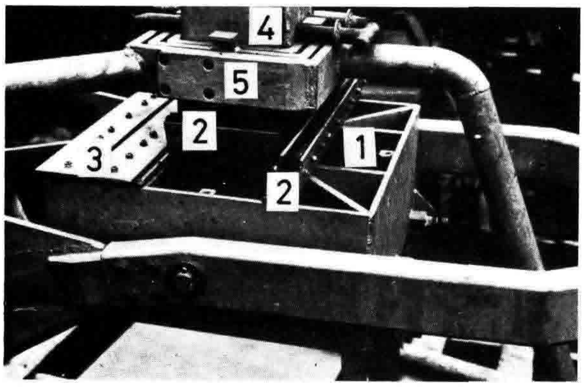
Explanation of Plate 1

Fig. 5. The box grab with its opened (2) and closed (3) top valves and the cross bars (1). The open area covers 52% of the box surface, allowing for a good water flux through the grab and reducing the bow-wave effect. The central column (4) is filled with removable lead, and (5) is the gimble frame.

Fig. 6. The 2.2 m^2 maxi VAN VEEN grab together with its normal sized 0.2 m^2 brother.

Fig. 7. The phototrap. On the left: camera (C) and flash (F); on the right: battery (B). The net chamber has 2 cone-like entrances (1 and 2); small plastic traps (T) are tied to the net. Bait (BT) is held in a bag and lies on the bottom netting.

Fig. 8. The closing trawl with the rectangular lever (RL) and the closing net (CN).



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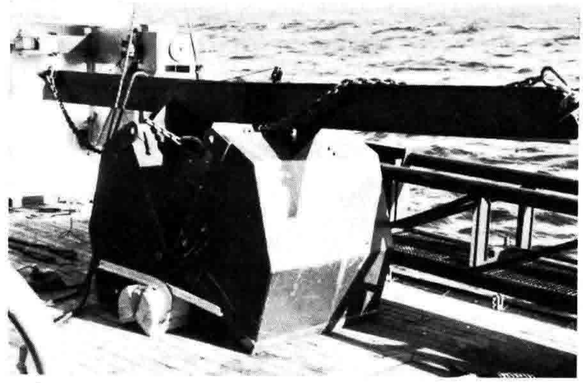

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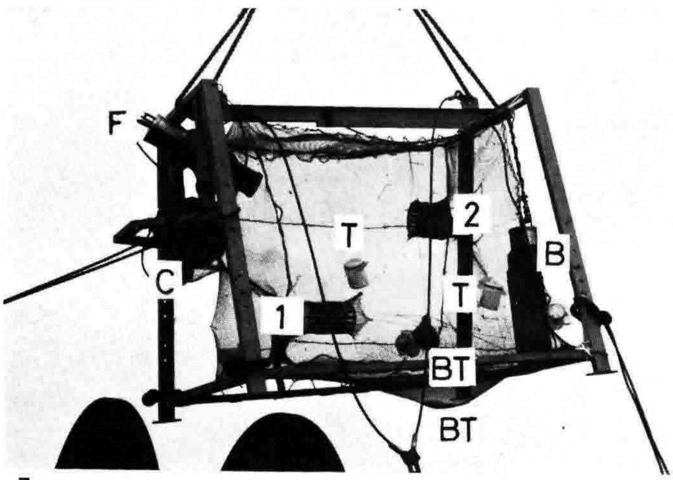

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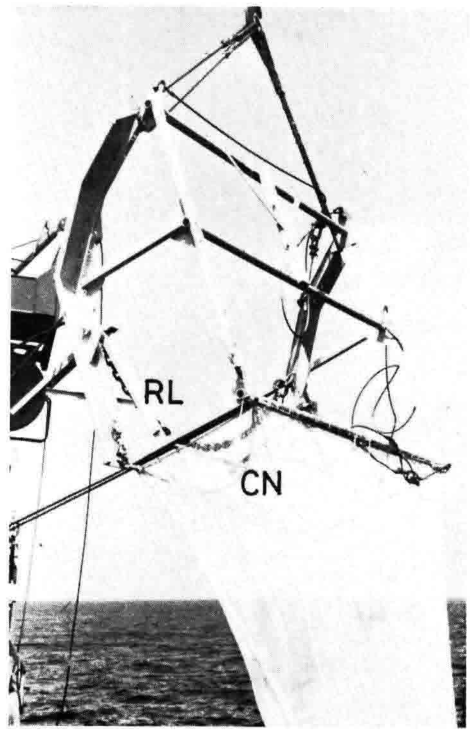

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