REMOTE SENSING SUPPORT FOR ANALYSIS OF COASTS (RESSAC)

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GEOLOGICAL SURVEY
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This report (to be considered as one of the deliverables of the RESSAC project) is relevant to the activities of WP 1000 of RESSAC project (data requirements). It deals with coastal planning instruments and programmes of Israel. It provides a description of the studied area (Central Israel from South of Haiffa to Jaffa and Ashdod port area) and of the coastal erosion phenomenon. It mentions the data gathered (EO data and ancillary data) during the implementation of this WP.

I CONTEXT OF THE PROJECT

1.1 Coastal environment pressure in Israel

The Israeli coastal area (190 km long) is the most intensively settled part of the country, and is increasingly exploited as an environmental resource. From the fifties onward the Mediterranean coast and the zone at the right East of it are exploited as urban substrate and a farming region, a recreation zone and a main traffic belt, a source of building materials and a region of waste disposal, as an outlet for sewage and as a groundwater recharge area. Moreover, along the thinly sand-covered water line, large areas have been seized for ports, power plants, industry and the military. Along the remainder (10-20 % of the total coast length) marinas, private beaches and hotels compete for space with bathing beaches.
The intensive usages often interfere with one other, and together they exert a heavy pressure on the natural environment with its pristine landscape, biotopes, historical sites and archeological remnants which, even if not destroyed outright, are heavily burdened by accumulation of man and seaborne garbage.

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1.2 Coastal erosion issues in Israel

Recent archeological findings in the nearshore zone and inner continental shelf of Israel, confirmed that the Israeli coastline has a negative sedimentological balance: fragile items such as human skeletons from the Neolitic Period, found on the sea bottom at 8 m water depth, or a 2,000 year-old merchant boat with all its merchandise intact, found in the surf zone, could not be preserved for such a long period of time if they had not been protected by a thick layer of sand. Indeed, the findings of these remains was possible due to the removal of the protective sand, not replaced by new deposits, thus indicating a negative sedimentological balance.

Except for its northen section (northward of Acre), the Israeli continental terrace is essentially the norhern-eastern limb of the Nile delta-submarine cone system. It is made of Nile-derived sediments transported from the Nile (and its predecessor) mouths and their vicinity (since 1965, as the river was dammed) by the shore-parallel counterclockwise south-eastern Mediterranean current system and by longshore currents and waves.

Coastal erosion is caused by the long-term Holocen transgression, and recently is greatly enhanced by human activity which interferes with the natural dynamic beach accretion and erosion progresses and exposes the coastal *Kukar* (fossiled carbonate-cemented sand dunes) cliffs to accelerated abrasion. There are two main types of anthropogenic interference in the natural sand transport on the Israeli coastline. The first one is relevant to sand, gravel standstone and beachrock quarrying along the beaches for building purposes, this very old activity was intensified at the beginning of the century, culminated in the 50's and 60's and was stopped in 1964 by the Israeli Government. The second one is relevant to the construction of various shore installations constructions (ports, harbors, marinas, water basins for power plants, detached break-waters, groins, sea walls, etc). Sand replenisment of the affected coastal area is very slow - and in some areas lacking -

if compared with the rate of beach destruction. The contruction of these infrastructures is often carried out without monitoring, clear documentation and forecasting of their impacts on environmental parameters.

Only few credible quantitative data exist on the rate of coastal erosion, despite several attempts to assess it. Various approaches were used to estimate the coastal changes and coastal processes, mainly through the comparison of aerial photographs taken from the same section of a coastline and *Kurkar* cliff edge at different periods, the comparison of aerial photographs and new photocadastric and topographic maps, estimate of the direction and rate of the longshore transport along the coastline, assessment of the *kurkar* cliff material lost by wave erosion, and direct measurements on the *Kukar* cliff edge. Relying on the data collection, the shoreline's retreat is estimated at 10 m up to 60 m since the mid 1940's (a rate of 40 to 270 cm/yr). Nevertheless, the research work carried out so far, has never been integrated to provide an overall view of the damage inflicted on the coast, and the erosional processes, nor has it ever been fully methodically and quantitatively assessed.

1.3 Outlines of the decision-making process in Israel and issues in coastal zone management.

Israel recognized the importance of Integrated Coastal Management in the early 1970's. Policies related to land use planning and to marine pollution prevention developed separately but have gradually become more closely integrated over the years. Attention is increasingly paid to the land-based sources of marine pollution and to the marine aspects of coastal land uses.
The land use planning system has provided an appropriate framework for much of the activities related to coastal zone management, both for the preparation of a national masterplan for the coastal area and for ongoing decision-making concerning proposed development projects.

1.3.1 Planning for Coastal Management

The main framework for coastal zone management in Israel is the Planning and Building Law. Through a hierarchy of national, regional and local planning Aurhorities, a special committee for the approval of offshore development, and a hierarchy of national, regional, local and detailed plans, onshore and offshore development is subject to a series of "checks and balances" to bring together requirements for development and requirements for resources conservation.
In 1970, the National Planning and Building Board recognized that Israel's coastlines should be treated as resources of national value, and issued an order for the preparation of national plans for all its sea and lake shores.
The first stage of the National Outline Scheme for the Mediterranean Coast was approved in 1983. The main objectives of the plan were to prevent development which does not need proximity to the coast, to protect large sections of the coastline as nature reserves, national parks and coastal reserves, and to allocate coastal areas for tourism and recreation activities. The masterplan included a highly effective clause prohibiting development within 100 meters off the coastline. Relaxation of this regulation is occasionally permitted only if approved by the National Board.

To help provide a comprehensive long-term guide to planning policy, beyond the general guidelines in the approved masterplan, the National Board commissioned a more detailed document for the resource management of the Mediterranean coastline for tourist and recreation activities. This coastal resource management plan, prepared by the Ministry of the Environment, was guided by an interministerial steering committee, including representatives of the Ministries of Interior, Transport and Tourism and of the Israel Lands Authority and Nature Reserves Authority, and a representative of the green NGO, the Society for the Protection of Nature in Israel (SPNI).
A multi-disciplinary team of landuse planners, geologists, ecologists and archaeologists prepared base surveys of coastal resources and set out guidelines for some of the main resource management issues.

The coastal resource management plan is based on principles of suitability and sensitivity of coastal resources. Each section of shoreline was analyzed in five parallel bands: deep water, near offshore waters, the beach, immediate hinterland and further hinterland. The resources were assessed by the planners in terms of their suitability for tourist and recreation activities and in terms of their sensitivity to the impacts of such activities. As a result of this qualitative assessment, the planners proposed that the leading principle for resource management of the coast should be the "intensity of development". Four levels of development were defined for beaches and their immediate hinterland, four levels of intensity of overnight visitor accommodation, and three levels of development of hinterland day-visitor areas. The level of intensity of development allocated to any site was related to the planners assessment of its suitability and its sensitivity.
The overall national policies proposed for resource management of the coast include:

* Development other than for essential coastal uses, including recreation or tourism, should not be permitted along the coast and its immediate hinterland;
* Policies for resource protection should range from absolute protection within a designated reserve to the identification of sensitive resources to be considered within the detailed plan for site development;
* Policies for recreation and tourist development should ensure that opportunities for a variety of daytime activity and overnight accommodation experiences are made available to the entire population of the country;
* Recreation and tourist development of the hinterland should be confined to centers. In order to protect as much open space as possible, linear development along the coastline should not be permitted;
* Highly intensive uses should be confined to existing urban centers;
* Sites not previously developed, where resources were identified as having recreation potential, could be designated for low intensity levels of development;
* Offshore construction for recreation and water sport activities should be restricted to urban centers.
* On the whole, the Mediterranean shore offers potential for the development of recreation opportunities far beyond the needs or forecasted demands of the population. The only area where resource potential is limited and will soon be scarce is the Tel Aviv shore. No development which further reduces the limited potential available there should be permitted;
* A public footpath should be designated along the coastline to ensure public access by foot to and along the coastline.

The principles outlined above have not only been accepted by the National Board for Planning and Building in the national coastal masterplan, but also incorporated into the newly revised Tourist National Masterplan, prepared by the Ministry of Tourism. Both masterplans are in advanced stages of discussion but have not yet received statutory approval.

1.3.2 The Territorial Waters Committee

The Territorial Waters Committee is a national level committee established under the Planning and Building Law for the approval of plans relating to marine structures.
Some form of committee existed in the Ministry of Transport prior to 1965, but the Planning Act transferred the responsibility to the Minister of the Interior. During the early years of its operation, it was concerned with the engineering aspects of marine structures or the possible interference of a structure on land or marine uses.
During the 1980's the committee became far more aware of the environmental aspects of marine structures, particularly in relation to interference in the sediment flow and the risk of coastal erosion. A representative of the committee participated in the steering committee of the National Coastal Masterplan. The committee required environmental impact statements on almost all marine structures and has included regulations on each site to reduce as far as possible the risks of coastal erosion. It has required the inclusion of beach protection measures, such as offshore breakwaters and has required systematic monitoring of changes in sediment loss and accumulation.
The committee nominated an environmental advisor and in 1991 a representative of the Ministry of the Environment was appointed as a voting representative on the committee, whilst the deliberations of the committee have become more and more environmentally oriented, they have still been related to each project individually. There has been a lack of appreciation of the overall, accumulative impacts of marine structures on the marine and coastal environment. At the same time, there are increasing pressures for development in marine and coastal areas, including proposals for various offshore structures and for offshore "islands" adjacent to the Tel Aviv urban coastline.
The Territorial Waters Committee took a decision that it needed a policy based on concepts of integrated coastal zone management. This represents another step toward coastal zone management in active, ongoing decision-making, to complement the ICZM in the national coastal masterplan.

1.3.3 Environmental Impact Statement

One of the most important tools in the land use planning process is the environmental impact statement (EIS). EIS has been used in Israel since the mid-1970's; regulations governing the requirements of EIS were promulgated under the authority of the Planning and Building Law in 1982. The regulations specify in which cases an EIS is mandatory and in which cases it is optional, upon request by the planning agencies (screening). An EIS is obligatory for four kinds of projects: power stations, airports, ports and hazardous waste disposal sites. The regulations strongly urge the preparation of an EIS for landing strips, marinas, main water carriers, dams and reservoirs, sewage treatment plants, quarries and waste disposal sites if the planning Authority considers that significant environmental impacts may occur beyond the immediate vicinity. In reality, the regional planning authorities regard this recommendation as mandating an EIS, since all such projects must have a significant impact beyond the immediate vicinity. The regulations also require an EIS if a proposed industrial plant is located outside a designated industrial area and its location, scale or operation may generate adverse impacts beyond

the immediate vicinity. While EIS for major urban and interurban roads are not included in the statutory list, nevertheless planning Authorities require the preparation of EIS for these projects. In fact, roads and associated facilities form the largest group of EIS commissioned.
In addition, any planning Authority (national regional or local) may require an EIS on any plan expected to have environmental implications, and every ministerial representative on the national, district or local planning levels may require an EIS for any plan under discussion. Since the Ministry of the Environment is represented in all the national and regional planning Authorities, it can exercise its right to require an EIS if the Authorities themselves do not do so.
In 1983, the coastal masterplan specified a requirement for environmental impact statements on all development projects in the coastal zone, unless exempted by a decision by the planning Authority. Successively, a later modification to projects within 200m. of the coastline has been required, unless specifically exempted by a decision by the planning Authority. EIS have been prepared for marinas, port expansion, offshore breakwaters, and tourist and hotel projects along the coastline. The regulations specify that the EIS be prepared in accordance with guidelines (scoping), formally issued by the planning Authority but prepared by the Ministry of the Environment. The Ministry invests special efforts in the preparation of appropriate plan-specific guidelines to ensure that the EIS - when submitted - will be a useful tool to decision-makers. Experience gained over the past few years shows that specifically tailored guidelines produce useful EIS documents.
An EIS includes five sections as follows;

* A description of the environment to which the plan relates, before its implementation;
* Specification of reasons for preference of the proposed siting of the plan and activities resulting from its implementation;
* A description of the activities resulting from implementation of the given plan;
* Specification and assessment of the projected environmental impacts resulting from the implementation of the plan, and measures suggested for the amelioration of adverse impacts;
* Proposed conditions to be included in the plan.

The developer is responsible for preparation of the EIS in accordance with the guidelines as prepared. While the regulations do not specify how an EIS should be reviewed, the Ministry of the Environment has examined all EIS since 1987. Experts review each EIS and the Ministry issues an opinion which includes a summary of the main findings of the EIS, the Ministry's conclusions about the assessment, and a list of recommendations for the planning Authority. In most cases, the planning Authority welcomes the professional advice it receives from the Ministry, and incorporates its recommendations in its decision concerning the plan.

1.3.4 The Impact of Public Participation on Coastal Management

Public participation in ICZM is limited but growing.
Public participation in the planning and EIS process are officially limited to the right to submit an objection during the period in which the plan is deposited for public comment. This right of objection does not exist at the national level outline schemes. Consequently, there was no right of objection to the National coastal masterplan.
However the largest environmental NGO, the Society for the Protection of Nature in Israel (SPNI), is a member of the National Planning and Building Board and actively

participated in the steering committee for the preparation of the Masterplan during the 1980's.
Moreover, the SPNI and a smaller more recent NGO, the Israel Union for Environmental Defense (IUED), are raising public criticism of on major coastal issues, such as:
- whether there is a need for the construction of more marinas,
- intensive development of coastal sites of high property value.

The SPNI and the IUED take major cases to the regional and the Supreme Courts including the Hof Hacarmel residential and tourist project in Haifa and the Yarkon marina in Tel Aviv. Public pressure, through the media, through the provision of expert opinions and through the courts, has an impact on decision-makers in the planning Authorities. The change of approach now apparent in the Territorial Waters Committee may partly be attributed to public pressure.

1.3.5 Coastal Sand Management

Increasing attention is being paid to how to manage coastal sand dynamics. To date, each coastal development project has been assessed individually, on the assumption that coastal engineers, relying on physical or mathematical models, can provide solutions to potential sand loss and coastal erosion. Herzliyya Marina has indicated that this is not the case. As a matter of fact, marine engineers recommended the construction of three offshore breakwaters north of the proposed marina, together with some beach nourishment from sand dredging. They concluded, on the basis of a physical sedimentological model, that no significant damage would occur to down shore beaches.
The results of the monitoring soon indicated that the erosion of the sandy beaches was far greater than it had been anticipated. It is still not clear if the reasons for this major discrepancy were inaccurate base data, an unsatisfactory model or an unexpected storm. It is also not clear whether the erosion was actually exacerbated by the "coastal protection" of three offshore breakwaters.
There are no simple solutions. Herzliyya municipality has requested permission to build additional breakwaters but the Territorial Waters Committee fears that this may merely move the erosion problem northward to the coast of the neighbouring local Authority and has requested an alternative solution based on ongoing sand renourishment.
The case of the Herzliyya Marina together with increasing information and understanding of sand flow are strongly indicating that case by case engineering solutions are not acceptable and that an overall sand management approach is needed. This issue will receive further attention by the Territorial Waters Committee in the future.

1.3.6 Ports and Marinas

The major marine structures currently under discussion are proposals for the expansion of the deepwater commercial ports of Ashdod and Haifa and the construction of several new sport-marinas.
There is no doubt that the deepwater harbours need to be expanded, since the current capacity is insufficient for even present needs and waiting times are too long. However, Ashdod port is the largest existing marine structure in Israel, which is believed to be blocking 60% of the total longshore sand flow and probably nearer 100% of the coarse sand which feeds the beaches. Its expansion will further increase the blocking effect. Present discussions with the Ports Authority, based on results of a mathematical sedimentological model, are focusing on solutions of sand by-passing or alternative sources of sand for beach nourishment, which would replace sand loss not only by the port expansion but also by the existing Ashdod port built in the 1960's.

Plans for marinas are currently under discussion among the planning Authorities. Haifa municipality has prepared a major land reclamation scheme and marina at the BatGalim-Shikmona beach, which will not endanger sand supply to beaches (as at Herzliyya) but may endanger the marine biological values of the submerged reef and offshore rock platform of Shikmona. It has also met with active public opposition from the SPNI and from local urban organisations. The proposal for an additional marina in Tel Aviv at the mouth of the Yarkon river has been required to apply to a sedimentological model to check whether the down shore north Tel Aviv beaches will be eroded and this proposal has also met with opposition to its proposals for major residential development instead of tourist uses.
Proposals for additional marinas are being questioned at a national level. Only some 1,000 anchorages are currently in use out of 2,000 now available, or will be available shortly, when the Ashdod marina is completed. Further marina development is therefore not motivated by the demand for anchorages but by accompanying plans for proposed urban development on coastal and reclaimed land. The Ministry of the Environment has requested the cancellation of at least four of the sites proposed for marinas in the 1983 coastal masterplan.

1.3.7 Offshore Islands

Academic ideas for offshore islands are now under serious consideration by an interministerial committee jointly with a Dutch government team. Proposals include offshore islands for urban development off the Tel Aviv and Herzliyya coasts and proposals for offshore airports. Current studies are focusing on potential offshore fill materials and possible impacts of islands on coastal morphology.

1.3.8 Tourism and Residential Development

Pressures for residential development in the central area of the country, from south of Tel Aviv to Haifa, are endangering future land reserves allocated for tourism. Whilst the tourist industry does not currently need the land reserves allocated to it in national masterplans, it may need them in the future. Such land reserves are in attractive locations, based on criteria of suitability for tourist development. Current demands for high-value residential property are seeking such locations. The planning Authorities are not always willing to refuse the demand of property developers and the result will be a loss of tourist land reserves. When the tourist industry recovers from a current slow period, it may then need to seek appropriate sites and will find itself in conflict with the "green lobby" who will be protecting attractive coastal open space from development.

1.3.9 Protection of Biological and Archaeological Resources

Conflicts concerning coastal development also arise where the protection of biological and archaeological on and offshore resources may be threatened, either directly by construction or indirectly by changes in sand erosion and deposition.
Offshore archaeological remains have been revealed by sand erosion.
On the other hand, sand deposition, even if relatively slight, can put at risk the flora and fauna of offshore reefs and wavecut submerged platforms.
One of the issues in discussions concerning the proposed Haifa marina involves the risk of additional sand deposition in the Shikmona offshore area, which could damage the valuable marine life within and outside the designated marine nature reserve.
In conclusion, increasing pressures for development along the Israel Mediterranean coast are generating conflicts between resource protection and economic development. The

national, regional and local planning Authorities are being required to take decisions which determine the future of the marine and coastal environment for future generations. The decision-makers are willing to consider any relevant information on coastal and marine resources and processes which can be presented to them in a way relevant to decision-making. The Ministry of the Environment, which is represented on all of the committees, tries to ensure that all possible relevant information is made available to the decision-makers.

II OBJECTIVES OF THE PROJECT

Recent findings have demonstrated that the Israeli coastline has a negative sedimentological balance, nevertheless, a comprehensive methodological and quantitative assessment of the damage caused to the coast and its erosional processes has never been undertaken. Therefore, a methodological approach which will integrate "conventional" geological and oceanographic studies with the analysis of satellite data is expected to provide useful information for the assessment of coastal erosion issues.

The RESSAC project will attempt at demonstrating the usefulness and cost-effectiveness of multi-satellite based data in the assessment and monitoring of coastal erosion phenomena and processes in Israel, by developing a "prototype" information system containing enhanced Earth Oservation products.

The outcomes of the project will contribute to the evaluation of the present coastal state and ist most recent evolution, to the assessment of coastal vulnerability to erosion and, most importantly, to the integration of remotely sensed and other information in the decision-making process on coastal planning. Moreover, the implementation of such a project will promote the introduction of advanced tools to the Planning Department of the Ministry of the Environment for resorting to methodologies using Earth Observation data, for on-going and future activities, and especially for coastal monitoring and follow-ups related to the impact of future interventions along the Israeli coasts.

As a matter of fact, the main quantifiable results of the project will be relevant to:

- the setting-up of a GIS prototype with updated information. This prototype will be a first step for the Planning Department towards the setting-up of a more comprehensive Geographical System for the management of the whole coastal area;
- the production of a coastal vulnerability map to erosion based on the integration of satellite remotely sensed data and in situ data;
- the evaluation of cost-benefits of the combined use of satellite remotely sensed and in-situ data against the use of only conventional data (in-situ surveys, airborne surveys) for assessing the coastal erosion processes in wide areas.

The project is also expected to contribute to the CEO programme by providing information, methodologies and demonstrations which will be useful for its development as well as for the design of additional programs in other coastal zones. Since the project involves groups from several European and Mediterranean countries, electronic facilities using standard communication channels (e.g. Internet) will be developed to promote data exchange (numerical, textual and graphic).

The integration of data from different satellites - optical and microwave - which have complementary geometric and temporal resolution, is expected to prove particularly useful and will ultimately contribute to the introduction of new customers to the use of remotely sensed data. As a matter of fact, the project is focused on monitoring and studying the following aspects, all of which relevant to a better understanding of the coastal erosion process in the test-area:

- shoreline changes
- coastal land cover assessment
- bathymetry assessment
- suspended sediment analysis
- sand inventory
- sea state and wind conditions

The satellite sensors will include:

- SPOT panchromatic
- LANDSAT TM
- NOAA-AVHRR
- ERS altimeter and scatterometer
- GEOSAT altimeter
- TOPEX-POSEIDON altimeter
- ERS-SAR mode wave and mode image

III CUSTOMER'S REQUIREMENTS

The Israeli customer has pointed out its main expectations from the RESSAC project, in connection with the planning department's goals (see §2.3), in particular relevant to the evaluation of each Environmental Impact Assessment established for new projects along the coast

Thus, the results and methodologies of RESSAC project:

a) could help MoE in taking prompt decisions by relying on updated information, in order to shorten the planning department's decision-making process on future coastal projects and to advise proper changes.
b) could provide it with the prerequisites to implement E.I.A. in a more cost-effective way.
c) could also provide indications to help MoE as for the improvement of erosion and sedimentation accumulation processes monitoring, around new off-shore constructions, in particular marinas.

In conclusion, any information based on the actual coastal environmental concerns which will be provided by the RESSAC project - even with the relative low precision related to the spatial resolution of the space sensor - is of high value for the Ministry of the Environment (Planning Department).

Nevertheless, the customer has defined more precisely, the followed success criteria:

- to identify the land use changes in coastal areas in order to allow the Planning Department to evaluate the discrepancy with the current masterplan;

- to identify changes in the shoreline at least in the last five years, in particular in areas where "marinas" have been built; this will reduce the need of airborne surveys and thus its use will be required only in specific areas;
- to locate seabottom sand areas (distribution and depth) to direct more specific surveys on seeking sand for beach nourishment;
- to assess the influence of sea characteristics on the sediment pattern dynamic along the coastline;
- to understand the influence of sea characteristics on cliff instability and sand erosion;
- to achieve a coastal vulnerability map (on selected areas) supporting the Planning Department in issuing recommendations relevant to activities in the coast (tourism, urbanisation and so forth).

IV THE STUDIED AREA

In the RESSAC project, the studied area stretches from South of Haifa (Hadera) and Jaffa, including the urban area of Tel-Aviv (Figure 1), and it is representative of the coastal issues met in the whole Israeli coastline. Moreover, it has been added the area of Ashdod which is characterized by a big port built in early 1960's and which causes an impact on sediment longshore transport, and as a consequence on the coastal stability of the area.

4.1 Land use characteristics of the coastal area between Ashdod and Hadera

The coastal area between Ashdod and Hadera constitutes the focus of urban and economic activity in Israel and is therefore under highly intensive development pressures.

The Tel Aviv municipality, together with Bat Yam, Holon, Azor, Ramat Gan, Givatayim and Bene Beraq form the main core of the Tel Aviv Metropolitan area, with a population of 966,000 at the end of 1996. This area is not increasing in population today - it is even undergoing a slight decrease. The area of increasing population is the ring that surrounds the main core area which includes Rishon leZiyyon, Petah Tiqwa, Herzliyya, Raananna, and a few other settlements, with a population of 610,000 at the end of 1996. A further ring reaches Ashdod in the south to Hadera in the north. Both of these cities are independent with employment opportunities in their area, but are regarded as part of the central region of major development activity.

The major issue of land use is the rapid change from agricultural use to urban uses in the outer ring and areas further out. The beginning of the 1990's saw significant spreading of low-density residential development in the area, with a major loss of agricultural land and open space and with a merging of once-separate residential communities. Previous agricultural settlements expanded and become urbanized as they absorbed new inhabitants who sought higher environmental quality in the rural areas. The spreading of urban development has been accompanied by an intensification of traffic congestion, particularly at peak hours, as more residents drive to and from work into the Tel Aviv central area. Public transport based mainly on buses, is still quite high by European standards, but the need for a modern mass transit system, whether bus, light rail or even

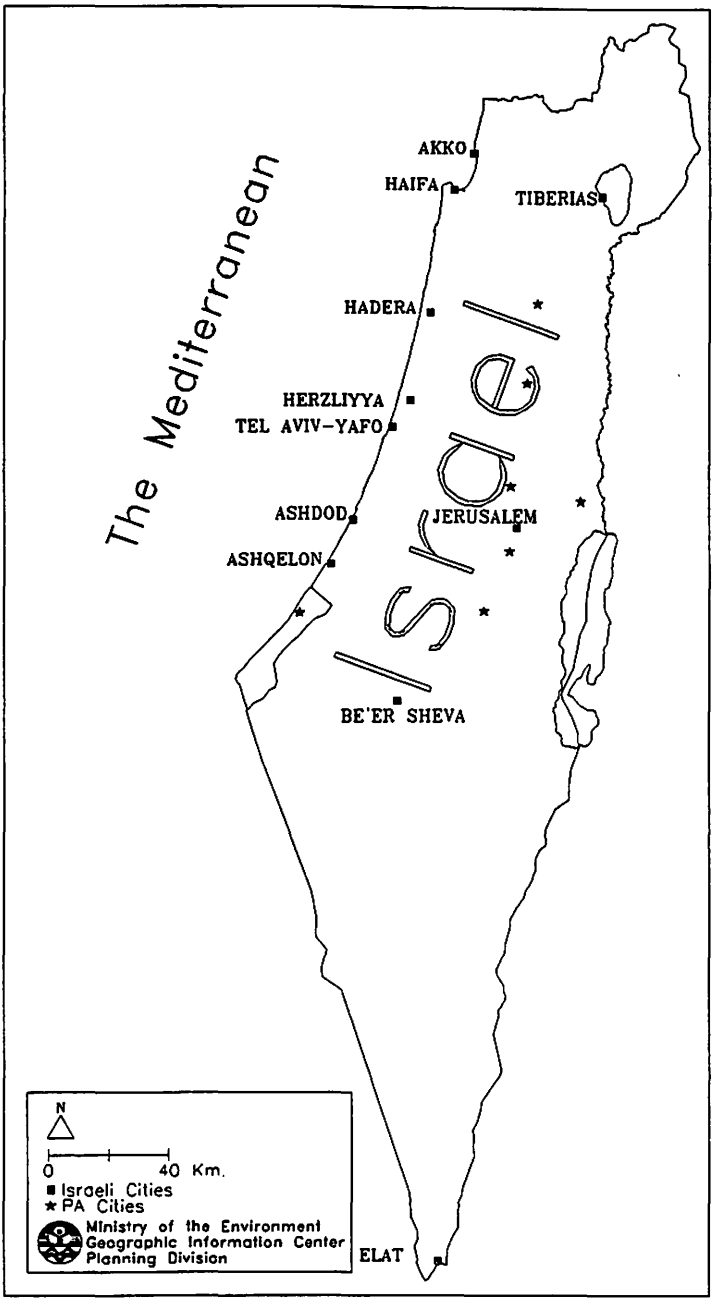


Figure 1. Map of Israel

underground, is becoming a crucial issue. The Tel Aviv Municipality sees the improvement and expansion of the existing mass transit system as a way of retaining its central focus and preventing the otherwise inevitable spillover of economic activities to suburban centres.

Besides being the centre of the country's financial and economic activities (not public administration, which is located in Jerusalem) Tel Aviv, Herzliyya, Rehovot and other parts of the Metropolitan area are the major centres of the hi-tech industry. Israel's present and future economic development depends on maintaining and furthering its hi-tech capability and its activity to compete in highly competitive world markets.

Whilst attempts have been made throughout the years of the State's existence to encourage population and employment growth in the peripheral regions, the hi-tech industry is not mobile enough and continues to concentrate where high-quality staff is available. It seems highly likely, therefore, that all the area along the Ashdod-Hadera coast will continue to be under highly intensive development pressures, particularly for residential development.

Agriculture is not only incapable of competing with urbanization but is also undergoing a reduction of landtake as more intensive production techniques are used. Land is therefore going out of agricultural use in the central area of the country.

Tourism is a major land use activity in most of the coastal communities. Tel Aviv itself is a major tourist centre, with a row of high-rise hotels along its sea shore.
Herzliyya and Netanya are similar, with increasing high rise development along the shore. Although tourism is not increasing at the rate anticipated when the peace agreements were signed, tourism is still expected to be a major land utilizer in the coastal area. Ashdod and Hadera have not, so far, become tourist centres but Ashdod hopes to join in when its marina, currently under construction, will be ready, together with accompanying hotels.

Ashdod is the centre for all kinds of industries with its deepwater port, power station and oil refinery. It has expanded very rapidly over the last few years, undergoing major residential construction largely for new immigrants from the ex-Soviet Union.

The importance of using land efficiently for residential purposes, is now stressed in land use plans in this area. Emphasis is placed, for example, on high density development. Emphasis is likewise placed on the need to protect open space for landscape and recreational purposes, not so much for agricultural production. In drawing up the plans, thought is given on how to prevent the agglomeration of all the separate urban areas into an unbroken metropolitan area. Particular emphasis has been placed on keeping green buffers between settlements, along river channels (Yarkon, Ayalon, Lachish, Sorek, Alexander) and along the coastal non-urban areas. Some of the river channels have been developed as parks, others are in the process of plans for rehabilitation, having been damaged in the past by pollution and neglect.

4.2 Geomorphological characteristics

The coastal plain and continental shelf of Israel consist of a system of subparallel longitudinal carbonate-cemented quartz sandstone (locally termed kurkar) ridges separated by longitudinal shallow depressions. The broadly concave shoreline cuts this ridge-and-depression system at a slight angle. Consequently, Israel's northern shoreline, from Mount Carmel to Taninim Creek, includes a continuous backshore ridge, whereas the coastal ridge along the central shoreline, from Hadera Creek to Yarqon Creek, is abraded, forming a prominent backshore cliff. In this 40-km-long stretch, known as the Sharon Escarpment, the cliff (and ridge) is at its highest (10-45 m). Southward, the ridges are not clearly aligned, causing irregular and widely spaced cliff sections.

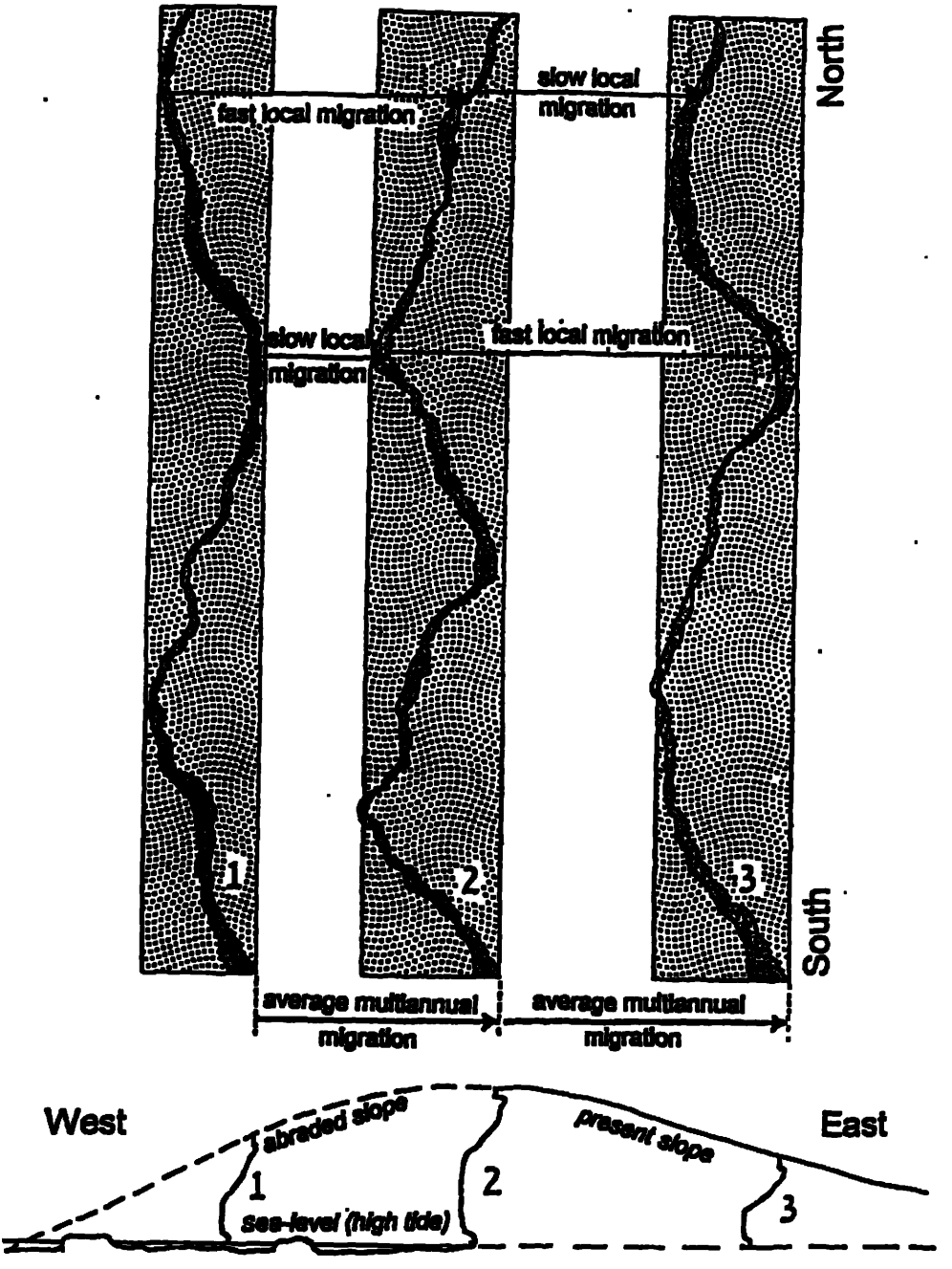
4.2.1 Description of the Sharon escarpment (kukar cliffs)[1].

The Sharon Escarpment between Giv'at Olga and Tel Aviv connects two regional land levels: the Coastal Plain, and the level of the Mediterranean beach and continental shelf, both of which consist of shore-parallel eolianite (*kurkar*) ridges and intervening troughs. The escarpment terminates the westernmost coastal ridge along its strike, parallel to the ridge crest. It is up to 45 m high and has 75-90° slopes, across layers of cross-bedded eolianite interlayered with up to 4 beds of loam, and it is capped by a ledge of hard calcarenite. The escarpment moves evenly eastward by discontinuous collapse on the seaward side. Rock slabs, commonly about 2 m thick and several metres long, become separated from the face of the cliff along tensional fissures, slide downward, and come to rest as 30-55° aprons of loose sand which are removed in seasonal stages by wavewash. No rockfalls occur as long as this talus protects the cliff's foot. The frequency of rockfalls, averaged over several years and along the entire length of the escarpment, is uniform and independent of cliff height or differential rock properties (Figure 2).

The escarpment's catchment area is small but steep, and runoff erodes deep primary gullies. Downwashed sand collects in low-angle fans in front of the talus and is removed with it. Even though erosion causes visible degradation (especially where connected to more inland systems and to artificial catchments, where it causes great damage), the volume of sediment thus removed from the escarpment is negligible compared to the volumes removed by slumps and rockfalls, and this erosion hardly influences the rate of cliff retreat.

Talus-free section along the escarpment, where the next expected event is a rockfall, were defined as risk A sections. Sandslides from wave-cut talus aprons mainly involve horizontal mass distribution (including riding blocks of detached calcarenite), and these sections were defined as risk B. Non-truncated talus was defined as risk C (no event expected before the onset of sand removal).
A slide cycle starts from the risk A situation. After a rockfall, a risk C situation is obtained, which through a sequence of B-C-B-C events, becomes risk A (Figures 3 and 4). According to observational estimates over the last decade, risk C lasts 1 to 2 years, risk B several years, and risk A up to 10 years and possibly more. The rate of retreat for the total escarpment is constrained by the overall strength of the cliff and by the wave

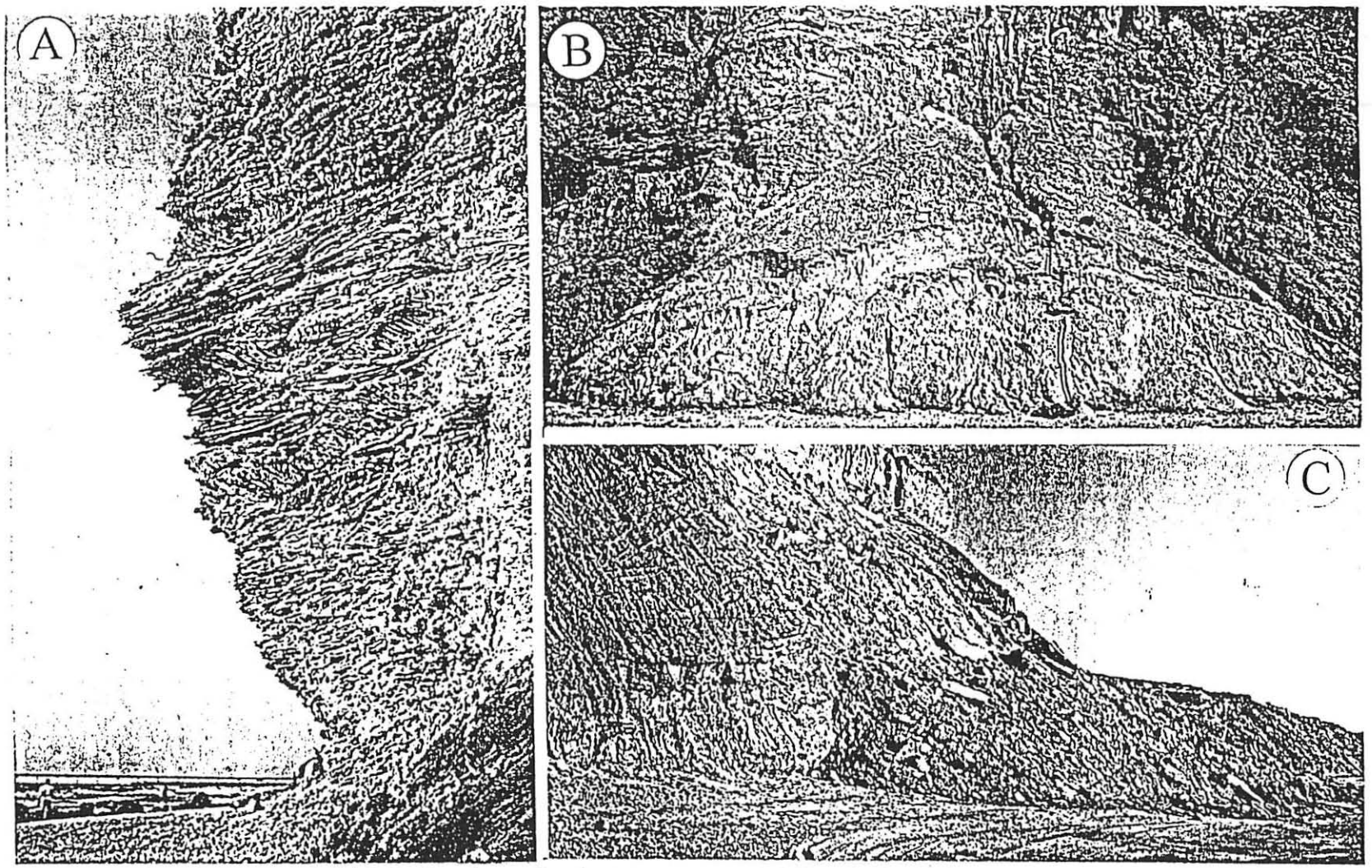
[1]From: "the Sharon Escarpment (Mediterranean coast, Israel): stability, dynamics, risks and environmental management". Report GSI/6/97, prepared by Itamar Perath and Gideon Almagor.



Cross Section: (1) Past - submerged and abraded kurkar reefs - remnants of the western part of the ridge; (2) Present - the Sharon Escarpment approximately coincides with the ridge line; (3) Future - ridge abrasion will reach the western trough.

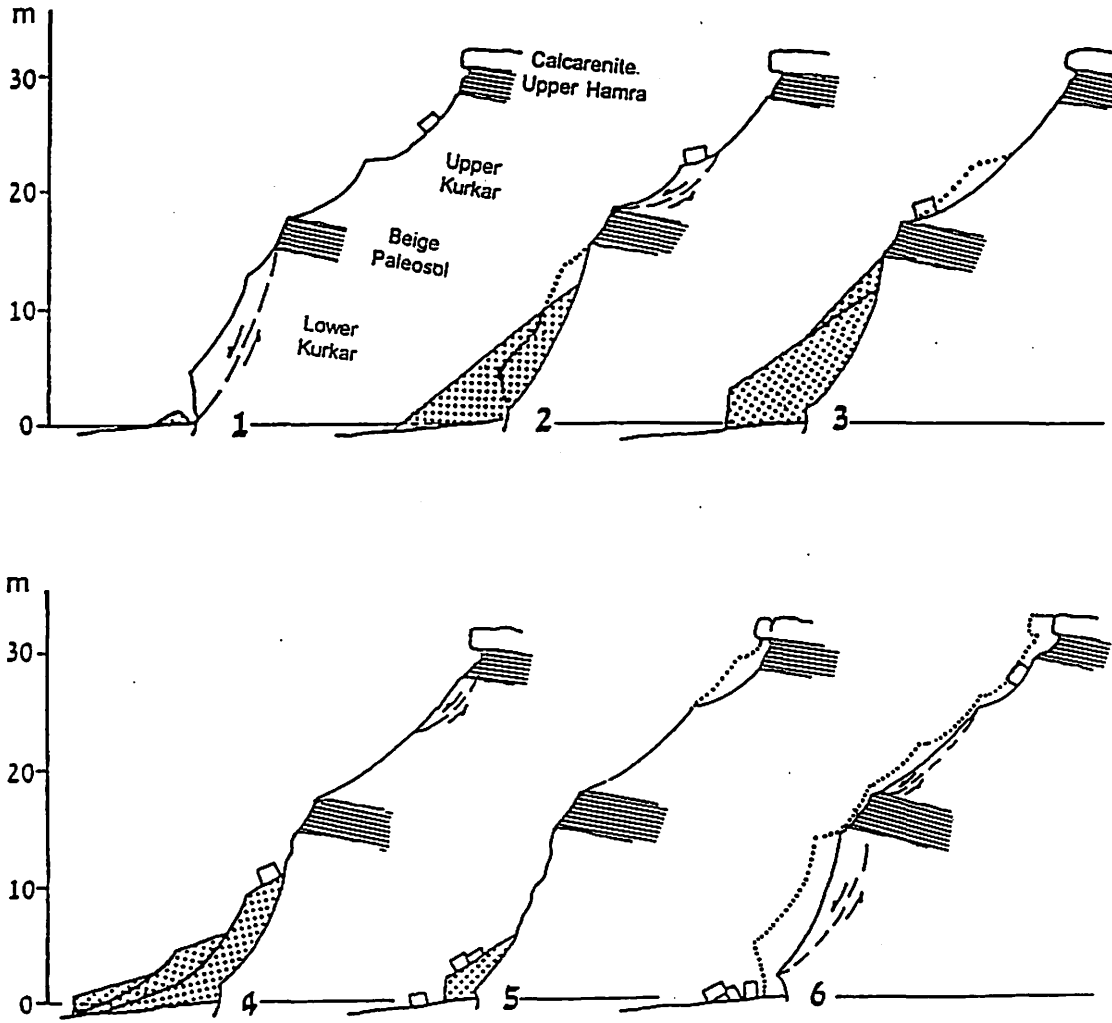
Planar projection: Local retreat of the escarpment (darkly dotted) may be haphazard, but on a multiannual scale, the ribbon delimited by the line that connects the escarpment's headlands and the line that connects its bights (lightly dotted) moves eastward at an even rate.

Figure 2: Stages of cliff retreat process.



A. Risk A - Pre-slump situation: steep, exposed cliff notched at its base.
B. Risk B - Pre-slump situation in talus: wave-cut, vertically stepped apron toe.
C. Risk C - No-risk situation: talus apron protects the cliff's base.

Figure 3: Illustration of some risks situation relevant to cliff erosion.



Risk cycle: 1 - A; 2 - Risk C; 3,4,5 - Risk B; 6 - Risk A. Dashed line - potential failure plane; dotted line - part of the cliff that slumped; hatched area - talus apron).

Figure 4: Illustration of some risks situation relevant to cliff erosion.

climate (*i.e.* the frequency of beach clearance of all talus). The rate of retreat is not perturbed by cliff height, by cliff angle or by cliff-top activity, as claimed by some authors, although one-time events may have a temporary or local effect on the short-range rate of retreat.

The Sharon Escarpment provides environmental benefits which may be irreversibly damaged by inexpert tampering with the topography.

In recent decades human interference has a measurable effects on the cliff retreat and cliff morphology:

- drainage (downcliff channeling of sewage, industrial runoff and/or artificially collected rainwater), road-building, back-cliff excavations (sand and calcarenite as building materials, soils as landfill and garden soil).
- construction of seaward projecting beach structures which interfere with the natural sediment balance along the shore, removal of beach sand, and removal of talus aprons which protect the cliff from abrasion.
- garbage (urban rubble and industrial refuse) dumping.
- slope grading to low-angle slopes (30° and less) in an effort to stabilize the cliff. The grading usually enhances run-off erosion. The maintenance of the slope requires large investments (terraces, soil-stabilizing vegetation).
- buttressing and aproning of the lower cliff with mansory and concrete.

4.3 Characteristics of the marine platform

The Mediterranean Coast of Israel stretches along some 180 km from Gaza in the south, to the Lebanese border in the north. With the exception of Haifa Bay, it is a smooth coastline which gradually changes its orientation from NE-SW in the south to almost N-S in the north. The coast may be divided into five geomorphological units:

- from the southern border to the vicinity of Tel Aviv the beach is 30-50 m wide, and backed by a low (5-7 m) bluff and wide (up to 10 km) dune fields;
- from Tel Aviv to the vicinity of Hadera the beach is narrower (0-30 m) and backed by a precipitous high (up to 40 m) cliff;
- from Hadera to Haifa the coast is of low profile with no bluff or cliff and, at times with small embayments - Haifa Bay;
- from Haifa to Akko, where the beach is backed by dunes;
- from Akko to the Lebanese border where the beach is mostly rocky with pocket beaches backed by a low cliff.

The orientation of the continental shelf follows that of the coastline, i.e., it is NE-SW in the south, changing gradually to N-S in the north. Its width (defined by the 100 m depth contour) also changes gradually from about 20 km off Gaza in the south, to 15 km off Tel Aviv, to 10 km off Haifa.

The continental shelf is generally smooth (Figure 5). The two major bathymetric features which can be noticed, are the Akhziv Canyon and Mount Carmel protrusion. Akhziv Canyon is located a few kilometers south of the Israel-Lebanon border. Its head is about 1.5 km offshore at a water depth of 20 m, its width is about 3 km at a water depth of 50 m and it extends to the continental slope. Mount Carmel protrudes into the sea to form what is locally called the "Carmel Nose". In this area, the shelf is shallower and the shelf

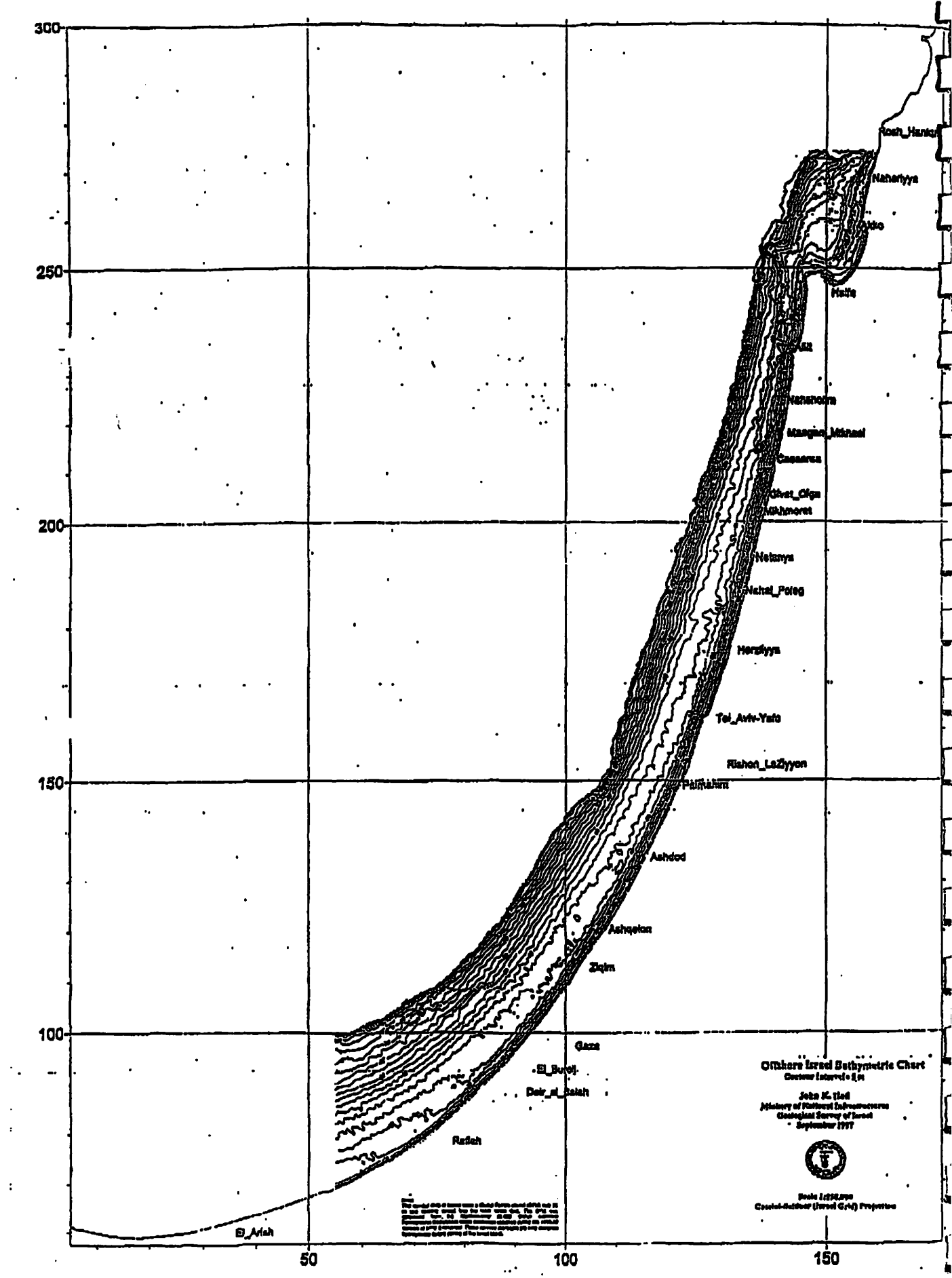


Figure 5: Bathymetric chart (- 5 m contour interval) reproduced from 1:250.000 map scale in Cassini-Soldner -Israel Grid- projection (by John K.Hall - Ministry of National Infrastructures- GSI- Israel ,1997)

break begins at 60 m. Bathymetry in this area is rugged, with many hills valleys and rocky outcrops.
Other irregularities on the continental shelf are submerged Kurkar (local term for calcareous sandstone) ridges. These ridges are elongated, parallel to the shoreline, with a relief of 4-8 m. In some cases they form islands and, when close to shore, these islands form tombolos behind them.

Most of the coastline, from Akko southward, is part of the Nile Littoral Cell. This cell which extends from the Nile Delta in Egypt to Akko in Israel, consists of input of quartz sand from the Nile River, transport of sand by the action of waves and currents eastward along the Sinai Coast to Israel, wind-blown sand from the beach landward to form the extensive dune fields in the northern part of Sinai, Egypt and the southern part of Israel (Carmel et al.,1984) and a sediment sink in Haifa Bay, Israel. North of Akko, the sand is meagre in its quantity and biogenic in its origin, consisting mostly of crushed shells, carbonaceous algae, carbonate pebbles and granules, and very little quantity of quartz grains. The grain size of the quartz sand gradually decreases with depth of water until it turns into silt and silty clay at water depths greater than 30 m.
In very general terms, the current regime on the Israeli continental shelf ranges between 0-70 cm/sec and is northward-oriented. During Spring and Fall Seasons the direction is variable and may also be southwards.

The coastal erosion (in the sense of waterline migration) is noticeable mostly next to the coastal structure but there is no hard evidence to coastal retreat all over the country. Along the Israeli coastline, three main coastal infrastructures have today an impact on sand longshore distribution: Ashdod Port built between 1960 and 1964, Herzliyia marina built in 1990 and the cooling basin of the Hadera power station built in 1978.
Nevertherless, there is though evidence that there exists a deficit in the sand budget of the Israeli coast. The causes for this deficit are: (a) an intensive mining of beach sand for building purposes since the beginning of the century until 1964 when the government prohibited this mining, and (b) sand which is captured behind coastal structures and removed in this way from the littoral system. Golik (1997) estimates that these activities have pirated some 20 million cubic meters of sand from the Israeli beaches since the beginning of the century.

V DATA ACQUISITION

5.1 Ancillary data

For a correct georeferencing, calibration and validation of remotely sensed data, various ancillary data have been requested. Hereinafter, the available data used in the framework of RESSAC project are introduced.

5.1.1 Cartographic and thematic data.

- topographic maps at 1:50.000 scale on the whole Israel coastal area.
- topocadastric maps at 1.10.000 scale which cover the area from Hadera and Tel-Aviv.
- Coastal Zone Lithology at 1:10.000 scale, provided on digital format. The Geological Map of the Mediterranean Coast presented the lithology for a coastal strip some 200-1000 m in width along three-quarters of the Israel Mediterranean coast. It was based

upon analysis of aerial photos and extensive geological reconnaissance. The original map was prepared by I. Perath, N. Bakler, and Y. Nir in 1981 at 1:10,000. Some seven different lithologies were identified:

- Clay and soil (brown)
- Hamra (red)
- Kurkar (orange)
- Eolian sand (yellow)
- Stratified sand (light green)
- Sea abrasion platform (medium blue)
- Calcarenite (dark blue)
- Fill and ruins (built up) (purple)
- Unidentified (dark gray)

In figure 6, is reported as an example, the lithology of the coastal area between Hof Poleg and Hof Ga'ash-Shefayim (centre of the studied area).

- Thematic data, including several national master plans, industry, rivers, roads, settlements, detailed surveys, etc. provided on digital format with a scale ranging from 1:10,000 to 1:250,000 (see annex 1, for more details):

- specific botanical surveys at 1:10.000 scale, in particular on Habonim coast vegetation (1997)
- built-up areas (1992, 1:50.000)
- settlements (1995) (names in Hebrew and in English, total population) divided into >25.000 and > 25.000.
- nature reserve areas (1995, 1:100.000): declared nature reserve, proposed nature reserve, declared national park, proposed national park, scenic reserve.
- afforestation (1996, 1:50.000): planted forest, natural forest (for conservation and for care), park forests, coastal park forest, planting on fluvial channels banks)
- rivers (1996, 1:50.000): tributaries, main rivers.
- industrial zones (1996, 1:50.000)
- quarrying and mining (1996, 1:50.000) with buffer areas
- waste-site areas (1997, point)
- landscape units and their relevant sensitivity (1997, 1.250.000)
- Habonim and Ashdod coast lithology (1:10.000)

A filter has been applied to the data and only part of them have been provided. This operation was aimed at checking subsequently the accuracy of the information data derived through satellite data analysis in areas where ground data have not been delivered. As a matter of fact, the maps covering the whole coastal area were divided into a 5 km x 5 km grid and the information has provided one cell on two. For the more restricted area (Habonim and Ashdod), the grid was 1km x 1km and the applied selection criteria was the same (one cell on two).

5.1.2 Data relevant to the marine platform.

Bathymetric data

The data relevant to two specific areas: Hadera and Ashdod, have been provided. The sea bottom in the vicinity of Ashdod Port and Hadera Power Plant was charted in May-June 1995 and in October 1995 respectively. The mapping was carried out using IOLR R/V "ETZIONA" equipped with a surveying echo sounder ODOM which provides depth

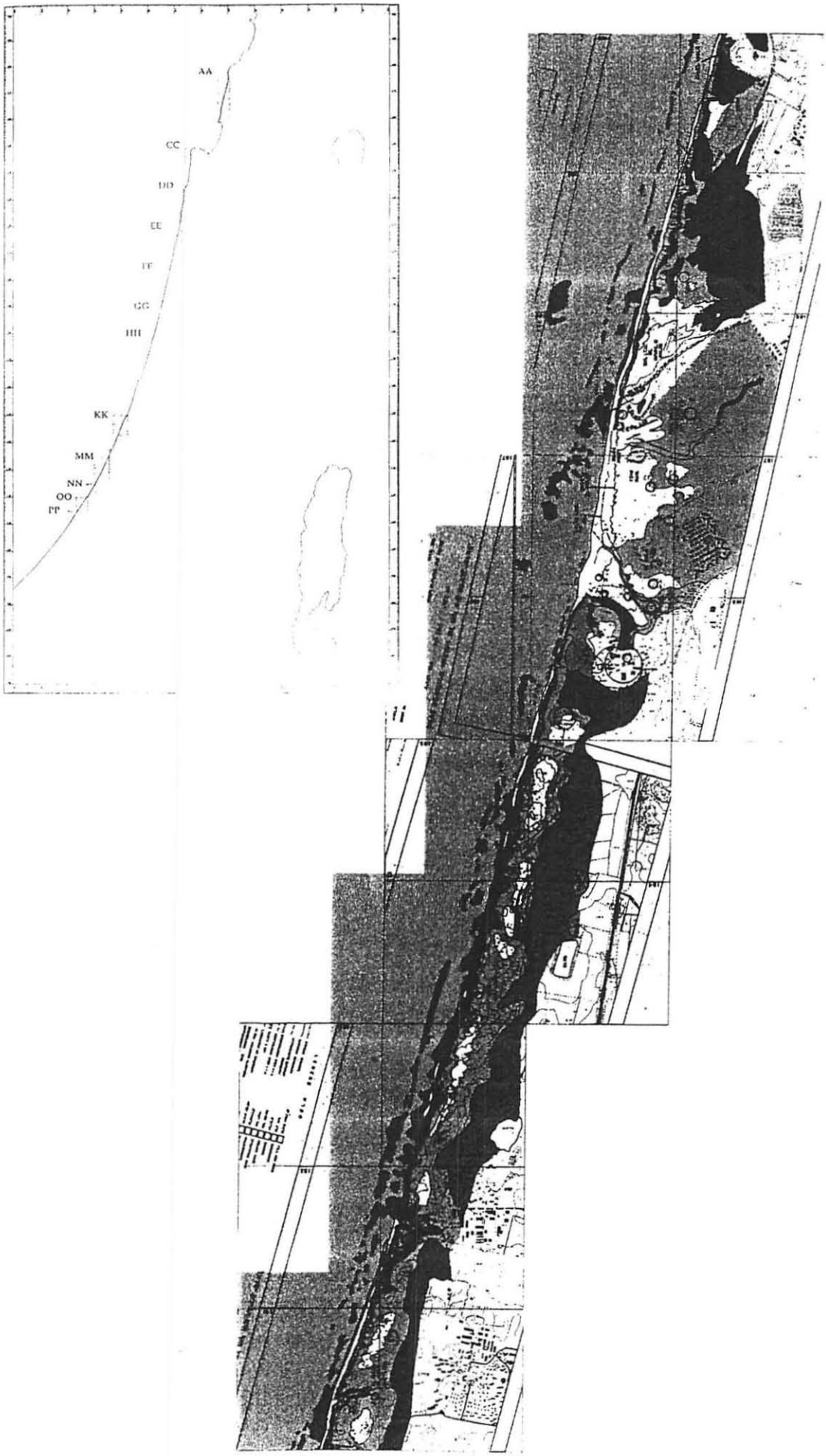


Figure 6: Coastal zone lithology between Hof Poleg and Hof Ga'ash-Shefayim (see site GG in the enclosed smaller map).

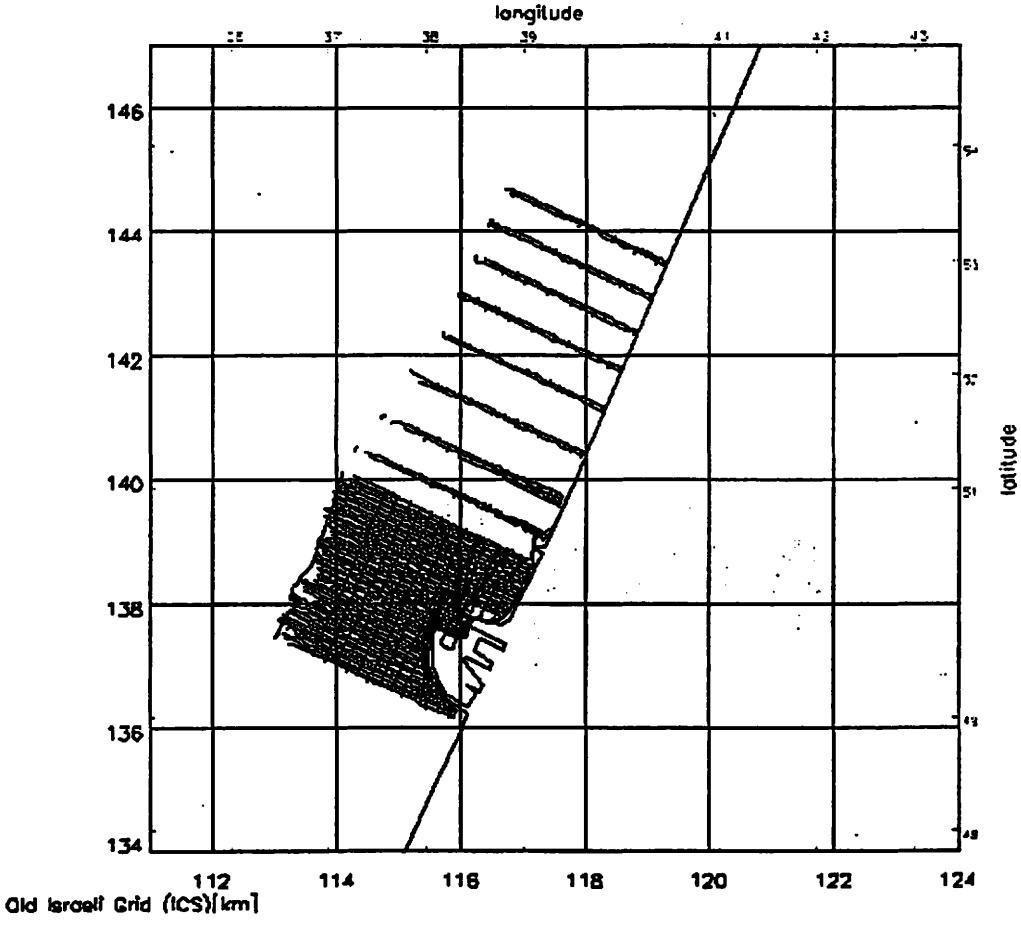


Figure 7: Distribution of some ship-surveyed tracks in Ashdod area in May-June 1995.

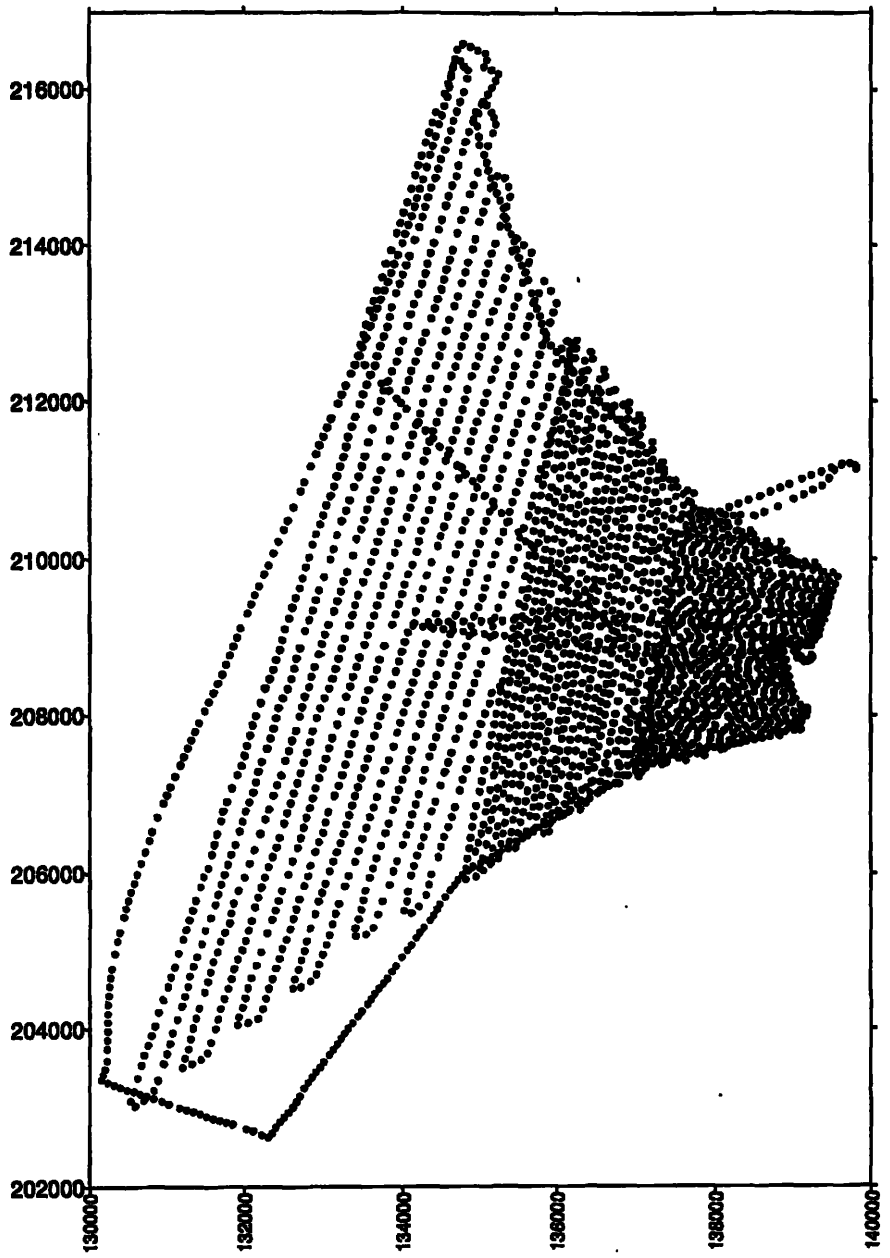
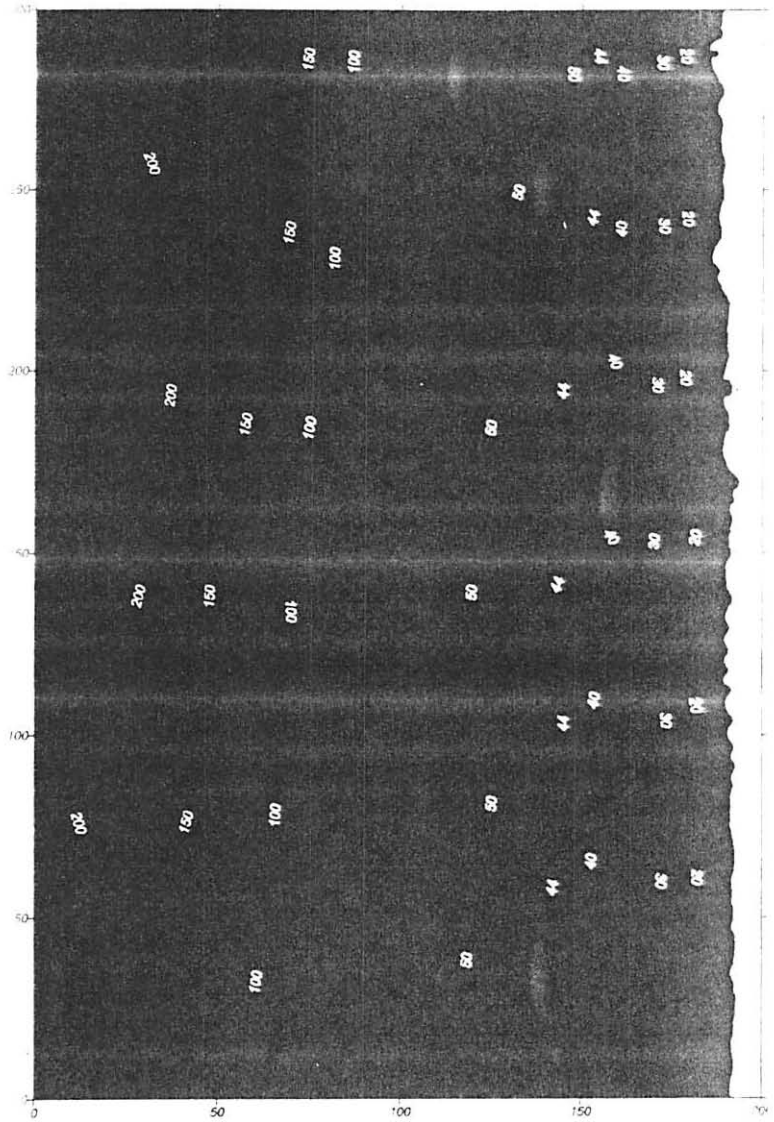


Figure 8: Distribution of ship-surveyed tracks in Hadera area on 10-18 October 1995.



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Figure 9: Sea bed topography of Hadera area as measured in the October 1995 survey

measurement with an accuracy of 0.5% of the depth, and a differential GPS navigation system which provides in a continuous way the position of the boat with an accuracy which is better than 2 m.
In Ashdod, the surveyed area had a rectangular shape and was 13 km long (along the shore) and some 3 km wide (to a water depth of 30 m). The survey was carried out along shore-perpendicular profiles spaced at 50 m intervals, as well as along several longitudinal profiles.
In Hadera the charted area is funnel shaped having the narrow side close to shore and the wide one in deeper water. Near shore the density of the profiles is high and their orientation is normal to the beach, whereas in deeper water their density is lower and orientation is shore parallel.
In order to examine the relationship between the density of the ground truth data and the accuracy of the chart obtained from satellite images, the data from these surveys were divided as follows:

- The Ashdod survey was divided into three sections: from one section all the measured depth data were provided; from the other, depth points from profiles spaced at 500 m interval were sent; and from the third no data at all were sent (Figure 7). The data set consisted of triplets (Longitude, Latitude and depth).
- As to the Hadera area, all the data have been provided (Figures 8 and 9). However, as the area covered is a triangle shaped, it has been asked to prepare a map which could cover a rectangular area - i.e., a map covering the area on which data are available - and, in addition, the two neighboring triangles on which data were not provided.

waves data

The wave measuring station at Hadera was installed in 1991 at the outer, western dolphin platform of the Hadera coal unloading terminal which is at a 27 m water depth, about 2 km off the shore. The monitoring unit, which was installed 10 m below sea level, is equipped with a 63512/DWG Pacer Systems Inc.instrument, consisting of a Digiquartz Paroscientific pressure transcducer, a two-orthogonal components Marsh McBirney current meter and YSI temperature sensor. These allow the measurement of directional wave spectrum, as well as of currents, water temperature and sea surface elevation (Rosen, 1993).
Waves data measured at Hadera station and relevant to specific dates are used subsequently in order to validate waves data provided by microwave satellites data and *processed* through the application of meteocean models for the construction of off-shore and on-shore waves database (see § 5.3.4).

5.2 Cartographic reference

The cartographic system for georeferencing Satellite images and subsequently for the GIS implementation is the **Old Israeli Grid**. The Old Israeli Grid has been selected taking into account that most of the spatial data provided by Israel are referred to this projection.
The parameters of this projection are:

- ellipsoid: Clark 80 modified
- projection: Cassini-Soldner

5.3 Remote sensing data acquisition

5.3.1 SPOT data

General characteristics of the SPOT satellite.

The SPOT program was started by France in 1978. It was realized through participation of France (main participant), Belgium and Sweden. The series of SPOT (Système Probatoire d'Observation de la Terre ou Satellite Pour l'Observation de la Terre) is made up of three satellites: SPOT1 (1986), SPOT2 (1990) and SPOT3 (1993), each satellite has a nominal life-span of three years. The orbits are pòlar sun-synchronous with an altitude of 832 km (revolution period of 101 minutes) and the repeating cycle is 26 days (daylight coverage only). Two kinds of sensors are installed on each platform:

1) HRV (Haute Résolution Visible) instrument with scanners which have a dual function: Multispectral mode (XS) with three spectal band in the visible (0.50-0.59 μm, 0.61-0.68 μm, 0.79-0.89 μm) and a spatial resolution of 20 m, and a Panchromatic mode (P) with one spectral band in the visible (0.51-0.73 μm) and a spatial resolution of 10 m. Each instrument covers a swath width of 60 km when vertically positioned, the swath width is 80 km when the instruments is angled 27° to the vertical.
2) DORIS (operational in case of SPOT2 and 3) is a tracking system for the determination of precise orbits (the same sensor is installed on the TOPEX/POSEIDON satellite).

One of the peculiar features of the SPOT system is its capacity for lateral sightings on both parts of the satellite's vertical by remote control of the orientation of HRV telescope mirror. This peculiarity allows the acquisition of pairs of stereoscopic images of the same scene in subsequent days from different angles at the time of passage (elaboration of Digital Terrain Models) as well as enabling a particular location to be imaged more frequently without waiting for an overhead pass (on special requirements).

In the framework of the RESSAC project, in order to assess the coastline changes on a 10-year period, the SPOT panchromatic images - with a spatial resolution of 10 m - appear one of the most appropriate tools for a multitemporal analysis of the coastal area and an evaluation of recent macroscopic changes.

Selection of the SPOT panchromatic images.

As for the selection of SPOT panchromatic imagery, the catalogue of Spot Images has been directly accessed through Internet and a series of the available quick look analysed. The selection criteria were the following:

- **period of acquisition**: no limitations have been placed. As for defaults, it ranges from January 1986 until today;
- **geographical location of the area**: by inputing either values relevant to Latitude and Longitude of the area or to the SPOT geographic reference system, in this case K118-J285 and K118-J286 (the K columns are arranged parallel to the satellite ground tracks, while the J rows are parallel to the line of latitudes) - considering

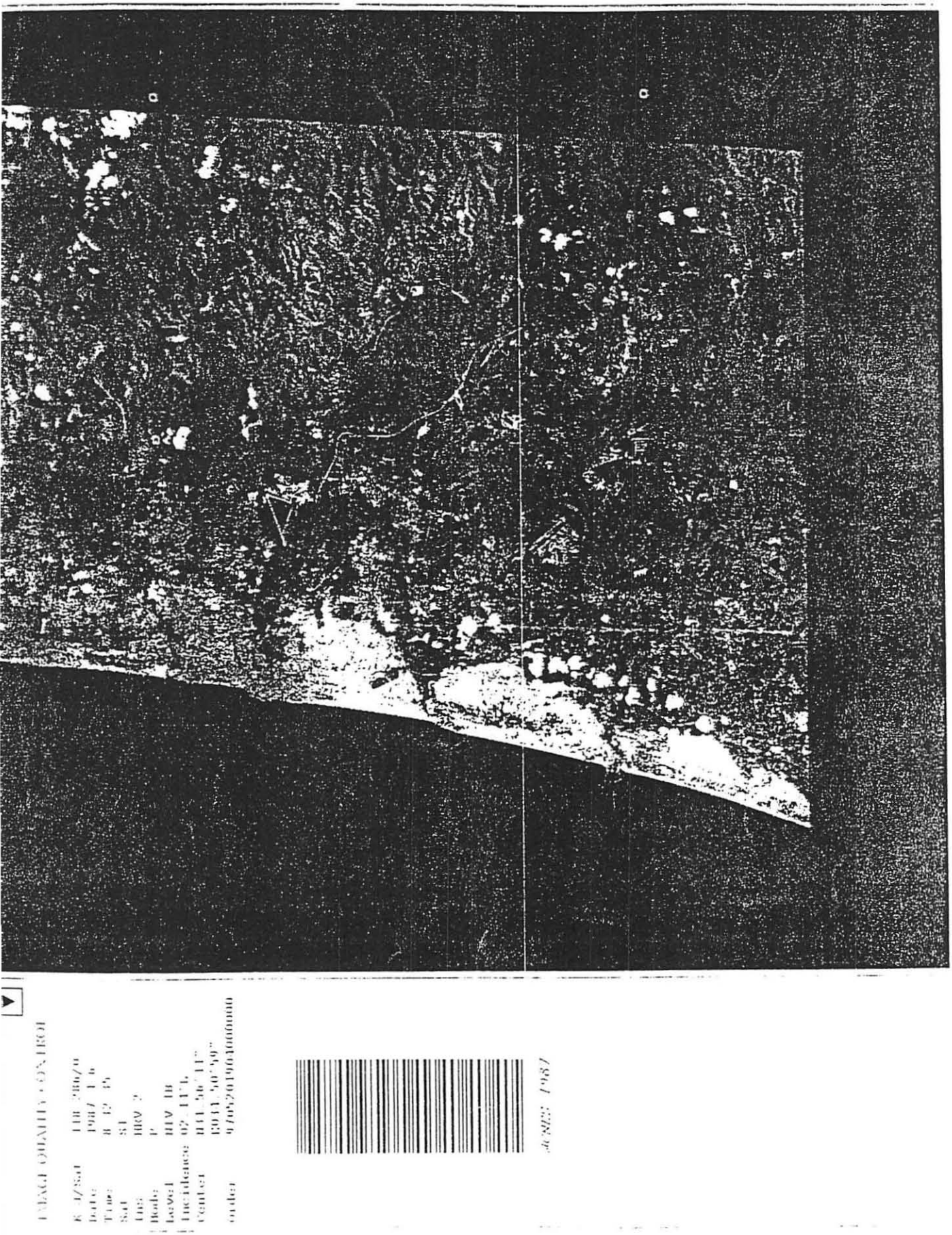


Figure 10: one SPOT panchromatic scene of April 1987 (raw data - track K 118-J286) framing the southern part of the studied area.

Figure 11: one SPOT panchromatic scene of October 1994 (raw data - track K 118- J285) framing the northern part of the studied area.

that two spot scenes are necessary for covering the area between Hadera and Ashdod.

- **other criteria such as: cloud cover, technical quality, spectral mode**: maximum cloud cover of 10% (class B), good technical quality, panchromatic spectral mode and a near vertical incidence angle.

Only 22 images have been found between August 1986 and November 1997 considering both K118-J285 and K118-J286 scenes. At the end, in order to consider a wider time range, two series of two scenes have been taken into account (Figures 10 and 11):

date (yy/mm/dd)	K (columns)	J (rows)	Spectral mode
87/04/06	118	285	Panchromatic
87/04/06	118	286	Panchromatic
94/10/07	118	285	Panchromatic
94/10/07	118	286	Panchromatic

Table 1. Acquisition dates of SPOT panchromatic images for coastline analysis.

5.3.2 Landsat data

General characteristics of Landsat satellites.

The series of Landsat satellites (NASA programme until 1983, NOAA management since 1983) has been existing since 1972, and presently, Landsat 5, launched in 1984, is still operational (Landsat 4, launched in 1982, failed in 1991, and Landsat 6 launched in 1994, failed almost immediately). As for Landsat 4 and 5, the orbit is polar sun-synchronous at a 705 km altitude (revolution period of 99 minutes) and the repeating cycle of 16 days.
Three kinds of sensors are installed on the platform:

1) MSS (Multi Spectral Scanner) with four spectral ranges for Landsat 4 and 5 (0.5-0.6 µm, 0.6-0.7 µm, 0.7-0.8 µm, 0.8-1.1 µm);
2) TM (Thematic mapper) operating in the visible (three bands: 4.5-5.2 µm -blue-, 5.2-0.6 µm- green-, 0.6-0.69 µm -red-), the near and far infrared ranges (three bands: 0.76-0.9 µm, 1.55-1.75 µm, 2.08-2.35 µm) with a a spatial resolution of 30 m and thermal infrared range: 10.4-12.5 µm) with a spatial resolution of 120 m. Each instrument covers a swath width of 185 km when vertically positioned.
3) RBV (Return Beam Vidicon Camera): Data transmission to ground station.

Land use analysis

Satellite remote sensing is an invaluable source of information about the identification and change monitoring in land use and land cover. The high resolution multispectral Landsat TM sensor makes it possible the identification and characterization of land features (basic cartography), as well as land use and vegetation cover (thematic cartography). In the RESSAC project, in order to assess and analyse the land use changes on a 10-year period: 3 Landsat TM images have been selected and acquired between 1987 and 1996.

The images have been selected considering the following criteria:

- temporal period: three images have been selected distributed over 10 years: one at the beginning, 1987; one in the mid-time: 1991; one at the end: 1996.
- covered area: the images have to be included most of the Israeli territory, with high priority for coastal area.
- other criteria: possibly free of clouds images have been selected.

The characteristics of the selected Landsat TM images are the following:

Platform	path	row	date	time (GMT)	scene	centre
Landsat TM	174	38	April 16,1996	07:20	035°27.00E	031°44.00N
Landsat TM	174	38	April 19,1991	07:33	035°45.00	031°45.00N
Landsat TM	174	38	April 24,1987	07:34	035°24.00E	031°45.00N

Table 2- Acquisition dates of Landsat TM images for land use analysis

In figure 12 an example of 1,2,3 band undersampled Landsat image relative to 1996 year is shown.

Sediment and bathymetry analysis

As for the bathymetry and sediment concentration assessment a Landsat Thematic Mapper (TM) quarter scene has been ordered and received from EURIMAGE. The recording dates of the image are listed in the following table.

Platform	path	row	date	time (GMT)	scene	centre
Landsat-5	175	38	June 8, 1995	07:23:42	034.36.00 E	032.05.00 N

Table 3. Acquisition date of LANDSAT-TM image (1/4 scene) for bathymetry and suspended sediment analysis.

The nominal resolution of the Landsat TM quarter scene is 28.5 m in both ground range and azimuth direction. The line and pixel spacing is 30.0 m. The scene covers an area of 90 km x 90 km. The Landsat TM quarter scene is projected on a UTM co-ordinate system, zone 36, using the WGS-84 reference ellipsoid. The Landsat TM quarter scene is shown in figure 13, this colour figure has been constructed using bands 1, 2 and 3.

The spectral bands 1 and 2 of the Landsat TM will be used for bathymetry assessment, whereas bands 1, 2, 3 and possibly band 4 will be used to study water suspended matter concentration, in this case, suspended sediment.

5.3.3 CASI data

As for the assessment of sediment concentration, imagery of the Compact Airborne Spectrographic Imager (CASI) from the Israeli coastline was acquired. The CASI data were collected on April 18, 1997, by Taldor-Navot Image Processing & Remote Sensing, Ramat Gan, Israel. The image data have been made available on three CD-ROMs. The recording parameters of the imagery is listed in Table 4.



Figure 12: one LANDSAT-TM image: April 1996 (color combination of channels 3, 2 and 1).

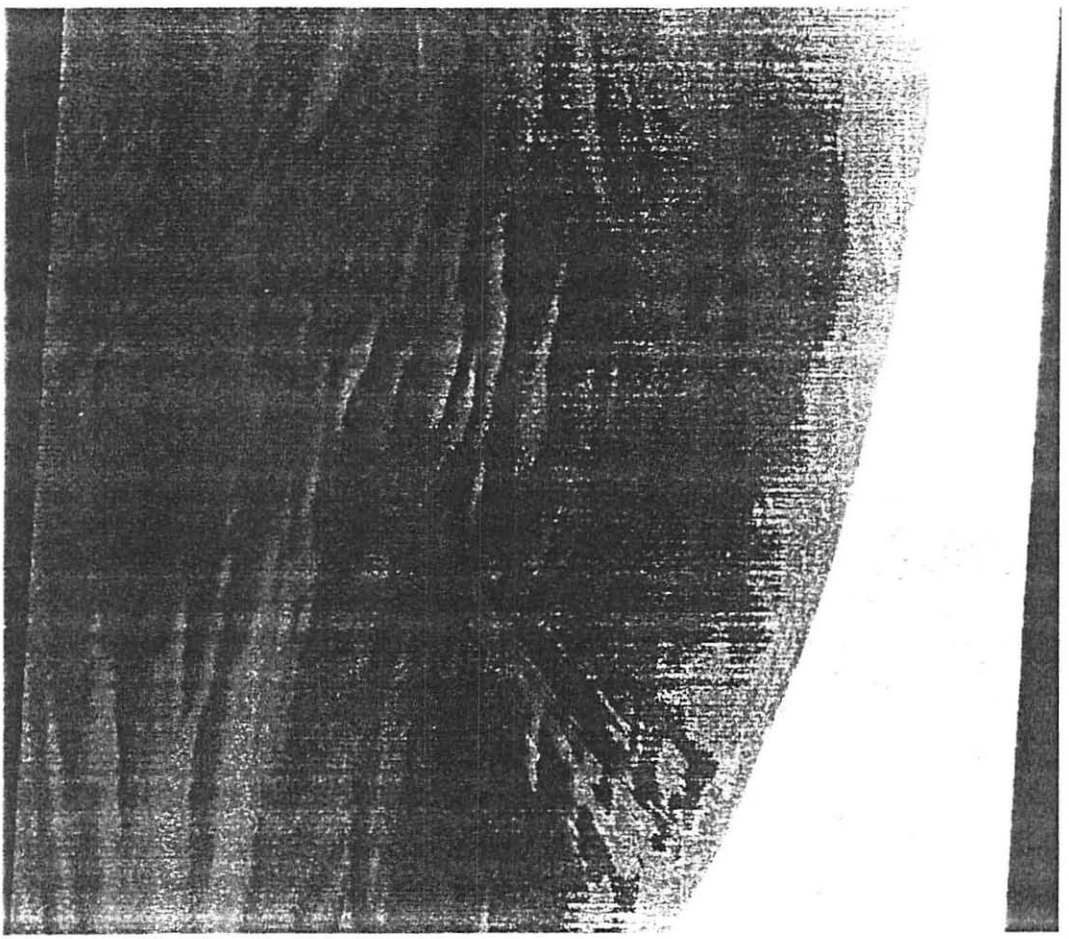


Figure 13: Landsat quarter scene (8 June 1995).

Track	Start time (local time)	End time (local time)	Direction	Speed (knots)	Altitude (feet)	Mode
Rosh-Haniqra to Atlit	09:42:54	09:54:16	N to S	130	9000	Spatial (19)
Atlit to Netanya	09:57:41	10:07:51	N to S	140	9000	Spatial (19)
Ashqelon to Natanya	14:22:24	14:42:39	S to N	130	9000	Spatial (19)

Table 4. Recording parameters relevant to CASI imagery of 18 April 1997.

The CASI imagery covers both the land and the sea. During image recording the plane flew above the coastline and tried to follow its direction. Therefore the plane did not fly on straight lines. This, and the fact that the stabiliser did not work, affected the quality of the data. The data have been corrected using two methods: (i) by correcting the roll (of each line) according to the gyroscope data and (ii) by performing a cross-correlation on the image. The image is geometrically corrected and is available on a grid, which runs parallel to the coastline. The grid spacing is approximately 3.5 m. Although geographical co-ordinates are available for each flight, the imagery is not geo-referenced. Furthermore, the imagery has been affected by Israeli censorship and several parts of the coastal area have been blanked.

The CASI imagery consists of 19 wavelength channels, listed in Table 5.

Channel number	start (nm)	end (nm)
1	438.4	447.6
2	460.6	478.9
3	480.8	501.2
4	505.5	516.1
5	525.4	536.6
6	546.0	557.3
7	615.8	625.2
8	627.1	636.6
9	644.2	655.6
10	661.3	672.8
11	674.7	685.0
12	689.9	701.4
13	702.2	705.2
14	745.3	751.0
15	756.8	764.4
16	774.0	779.7
17	800.8	808.5
18	818.0	827.6
19	841.0	848.6

Table 5. List of CASI channel wavelengths.

As an example, the outlet of the Yarkon river area just South of the airport of Tel Aviv is shown in Figure 14. This colour figure has been produced using channels 2, 10 and 18 (It must be noted that the airport was blanked).

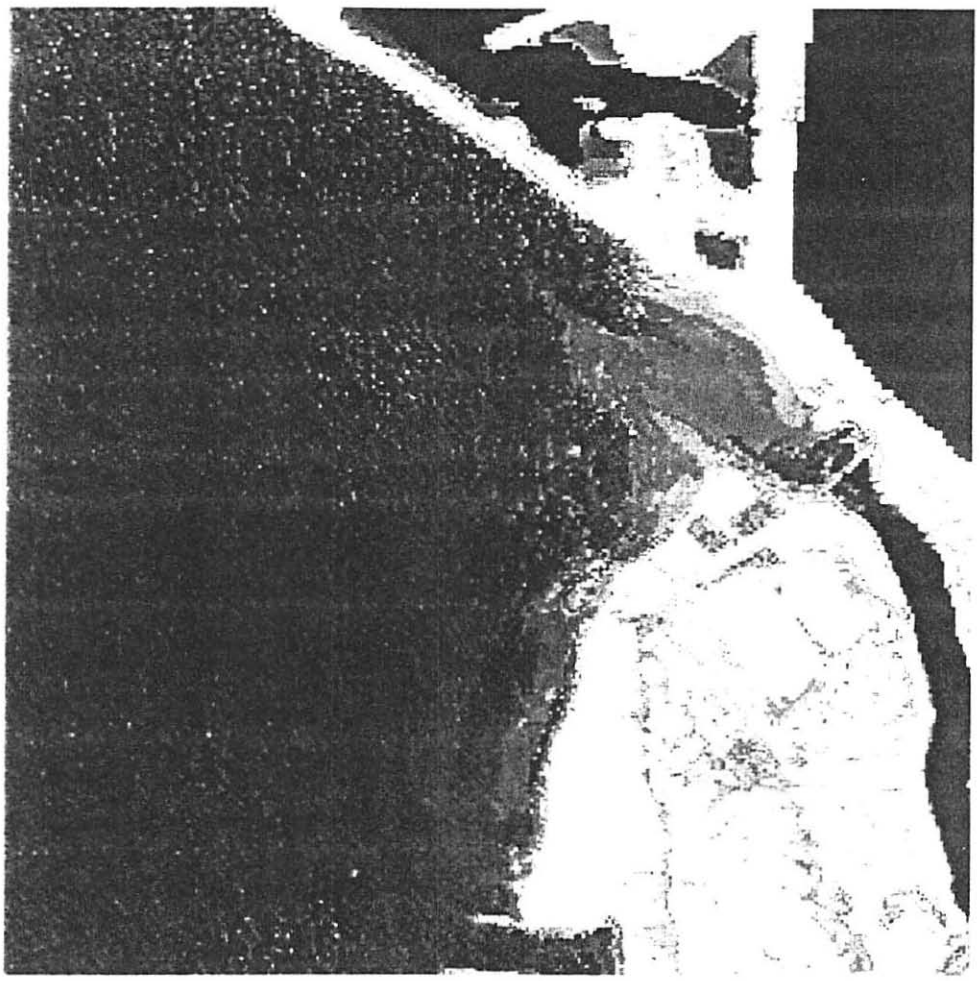


Figure 14. CASI imagery of the Yarkon river's outlet. Size of the area: 900 m x 900m approximatively.

5.3.4 NOAA-AVHRR data

General characteristics

The NOAA-POES program promoted by the U.S. National Oceanographic and Atmospheric Administration (NOAA), has evolved over several generation of satellites, starting in 1960 with TIROS-1 until the most recent operational satellite NOAA-14 launched in 1994. Generally, all these satellites are planned to have a time duration of three years. The most recent satellites include:

- NOAA-11 launched in September 1988 with a descending orbit (passage over the Mediterranean area at about noon and midnight) - out of operation from september 1994;
- NOAA-12 launched in May 1991 with an ascending orbit (passage over the Mediterranean area at about 6 am and 6pm);
- NOAA-14 launched in December 1994 with a descending orbit, assures the continuity of NOAA-11.

The orbits are sun-synchronous at an altitude of 800-850 km. The NOAA-POES cycle is of 12 hours and 11 days. Ten sensors are installed on each platform. Among them, the AVHRR scanner (Advanced Very High Resolution Radiometer), planned for the measurement of cloud coverage, sea surface temperature and vegetation, operating with a ground resolution of 1,1 km in the following spectral ranges:

- 0.58 - 068 μm (visible)
- 0.72 -1.18 μm (near-infrared)
- 3.55 -3.93 μm (thermal infrared)
- 10.3 - 11.3 μm (thermal infrared)
- 11.5 - 12.5 μm (thermal infrared)

Full resolution data (1.1 km) relevant to spectral areas of the world can be recorded in the LAC (Local Area Coverage) mode, or transmitted directly from the satellite in High Resolution Picture Transmission (HRPT) mode for areas with a radius of 2500 km of receiving station. Lower resolution (4km) GAC (Global Average Coverage) data are recorded on board, after resampling of the full resolution data and distributed as GVI (Global Vegetation Index) with a 15 km resolution.

Total suspended matter analysis

In the framework of RESSAC, NOAA-AVHRR data are used to perform a spatio-temporal characterization of the middle-scale suspended sediment concentration in sea water along the coasts of Israel on one year, exploiting the high temporal acquisition frequency of the satellite (one daily image).

As a matter of fact, though AVHRR is not optimized for ocean color monitoring, it is possible to use water reflectance on channels 1 and 2 to make an evaluation of the Total Suspended Matter (TSM), a parameter related to the suspended sediment concentration

40 NOAA-AVHRR daily images have been acquired (at the Telespazio's Scanzano station in Sicily) in order to perform this analysis. All these images were relevant to 1995 and selected according to the following criteria:

- minimum or no presence of clouds over the sea area of interest;

- uniformely distributed over the four seasons, in order to perform a correct spatio-temporal statistical characterization of the sediments.

An example of AVHRR image is shown in figure 15.

5.3.5 ERS and other radar data

General characteristics

Besides, the optical satellites introduced before, the microwaves (radar) satellites - which can acquire data in all weather conditions - have been used in the framework of RESSAC for the study of marine environment, in particular for the assessment of platform bathymetry and for the analysis of the sea state (winds and waves) in some specific points of the studied coastal area (Hadera and Ashdod):

- Geosat (radar altimeter) which has provided data for the period of March 1985 to September 1986 and November 1986 to December 1989.
- ERS 1 and 2 (radar altimeter, scatterometer, SAR [Synthetic Aperture Radar] in wave mode and image mode), ERS 1 has been launched in July 1991, ERS 2 in April 1995.
- Topex/Poseidon (radar altimeter) launched in August 1992

Radar Altimeter

The Radar Altimeter is a nadir-pointing pulse radar which is designed to measure echoes from ocean and ice surfaces. It has two measurements modes, optimized for measurements over the ocean and ice. In the ocean mode, it is used to measure wave height, surface wind speed and sea surface elevation. In the ocean mode, the echo characteristics to be used are:

- the time delay with respect to the transmitted pulse - this provides the measure of altitude;
- the slope of the echo leading edge, which is related to the width of the height distribution of the reflecting facets, and thus to the sea state Hs [(1)]; and
- the power level of the echoed signal, which depends on small scale roughness and thus to the nadir wind speed.

[(1)] Hs is the significant wave height defined as average of the highest 1/3 of the wave heights calculated either as Hmo or Hσ; mo is derived from the spectral density and σ from the associated water surface elevation which is function of time, in theory: mo = σ^2.

Geosat (November 1986-September 1989), ERS 1 (from December 1991) and Topex-Poseidon (from April 1992), provide offshore Hs and wind intensities (ff) parameters every second (or every 7 km) along their ground tracks. This value is very similar to the current engineering practice field Hs over a 20 minutes duration. Figures 16, 17 and 18 show examples of altimeter cycle, respectively as for Geosat, ERS and Topex/Poseidon, near the Israeli coasts.

At the present time, these satellites provide around 8 years of dense and homogeneous Hs data throughout the world. Once some corrections and qualifications are performed, altimeter measurements will offer reliable Hs statistics, with precision and confidence

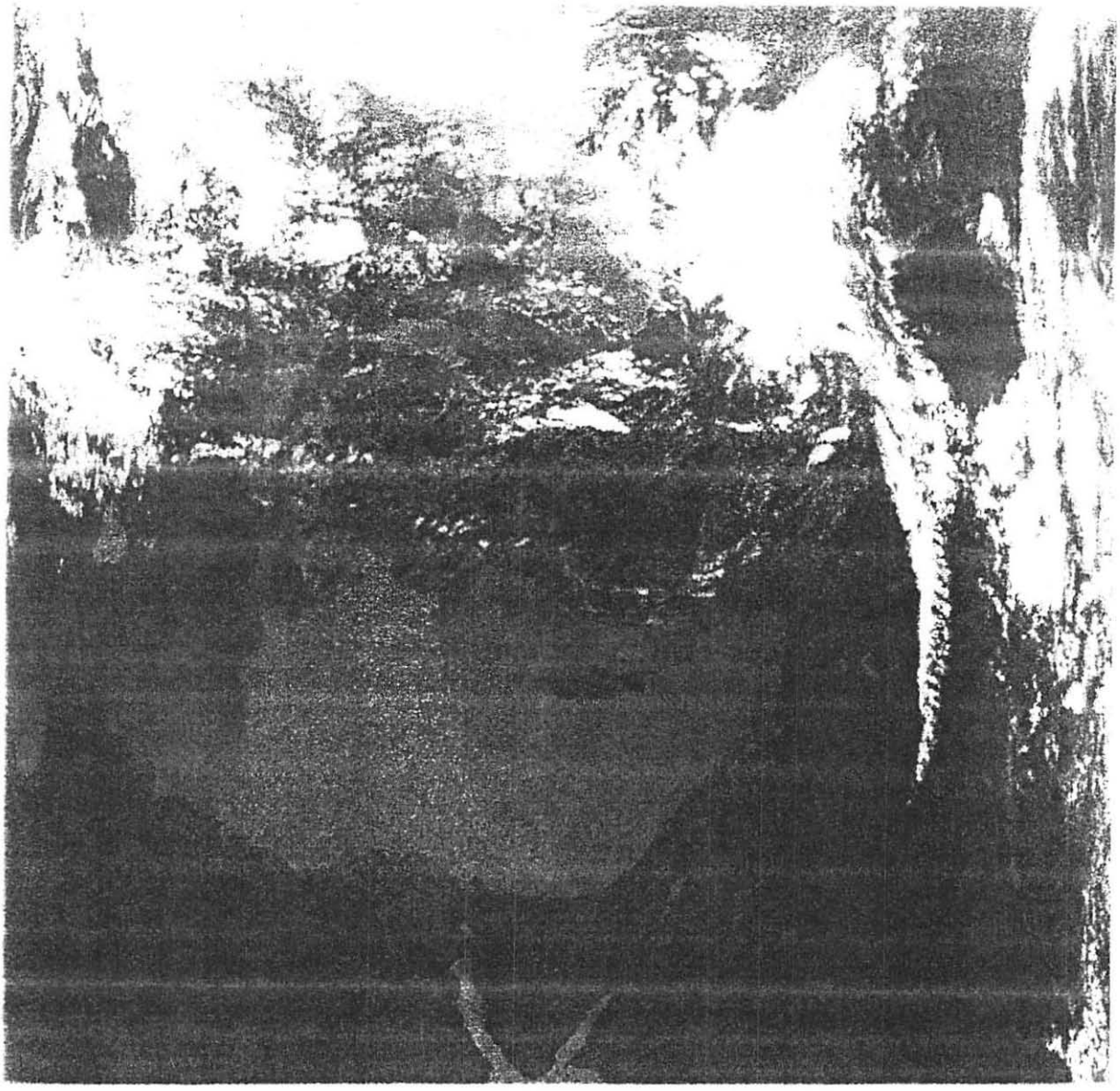


Figure 15. Example of NOAA/AVHRR image: 20 May 1995 (false color combination of channels 1,2 and 3).

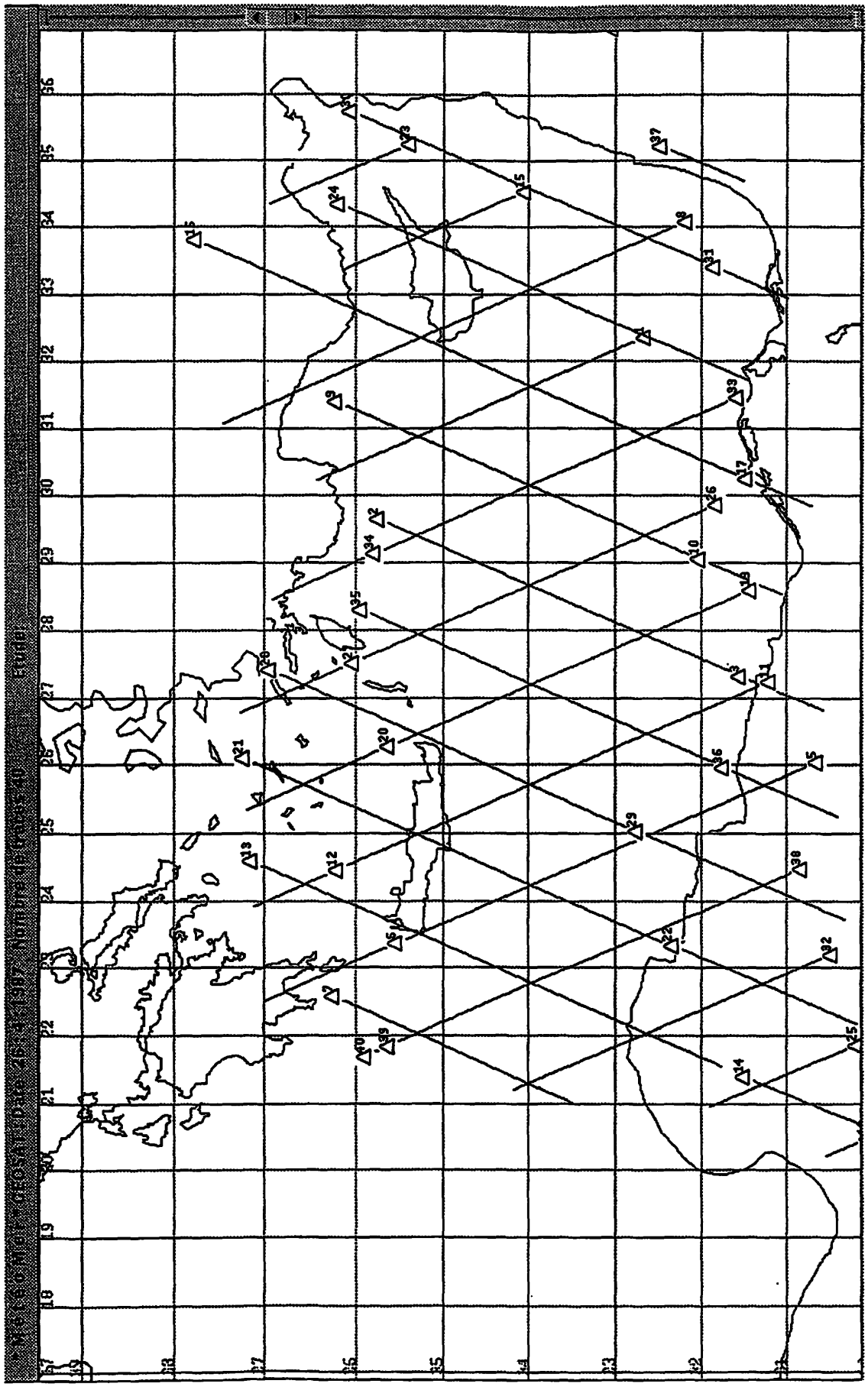


Figure 16. Example of ground tracks relevant to a 17-day repeat cycle (ascending and descending orbite) of GEOSAT (altimeter).

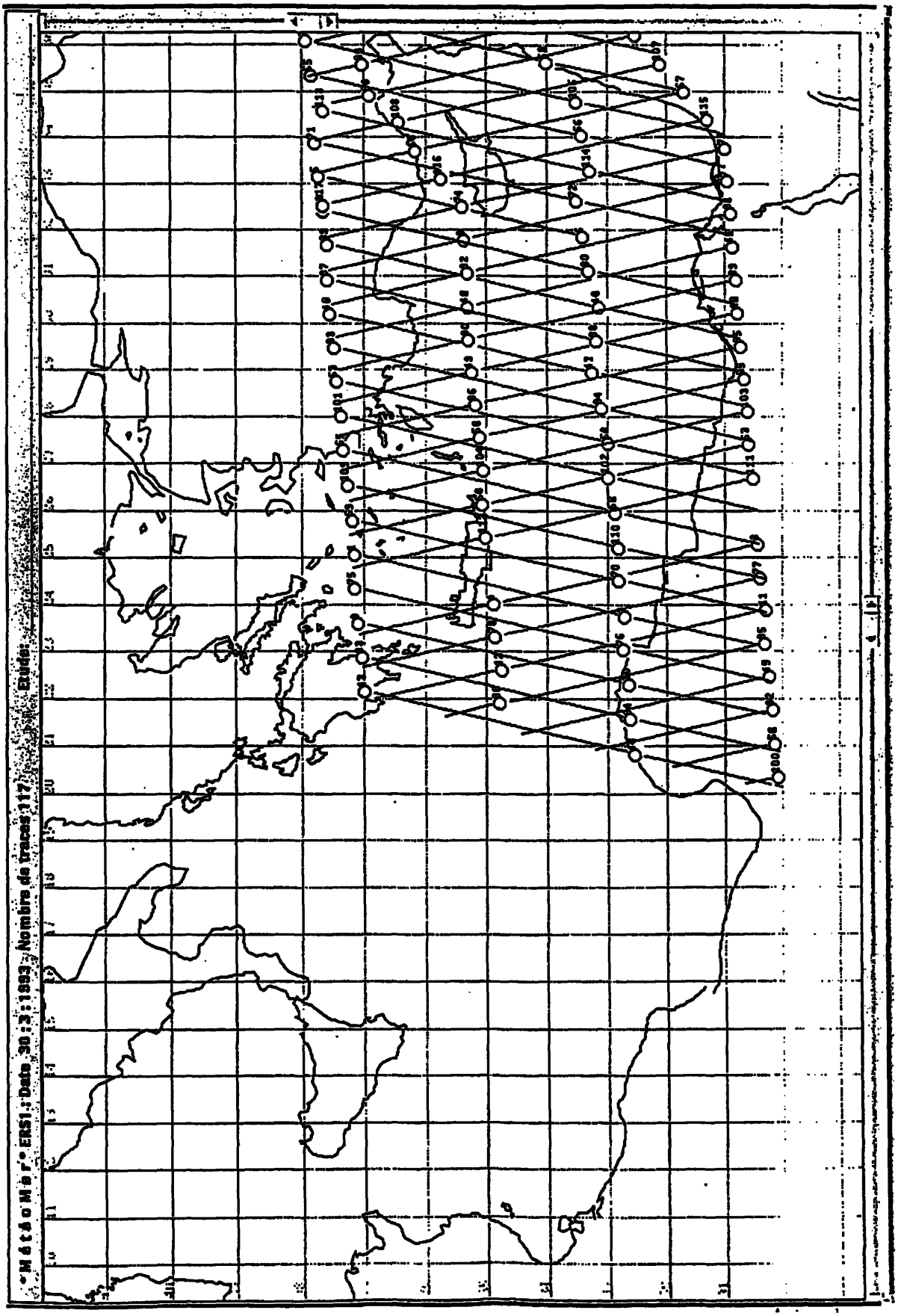


Figure 17. Example of ground tracks relevant to a35-day repeat cycle of ERS1 (ascending and descending orbit).

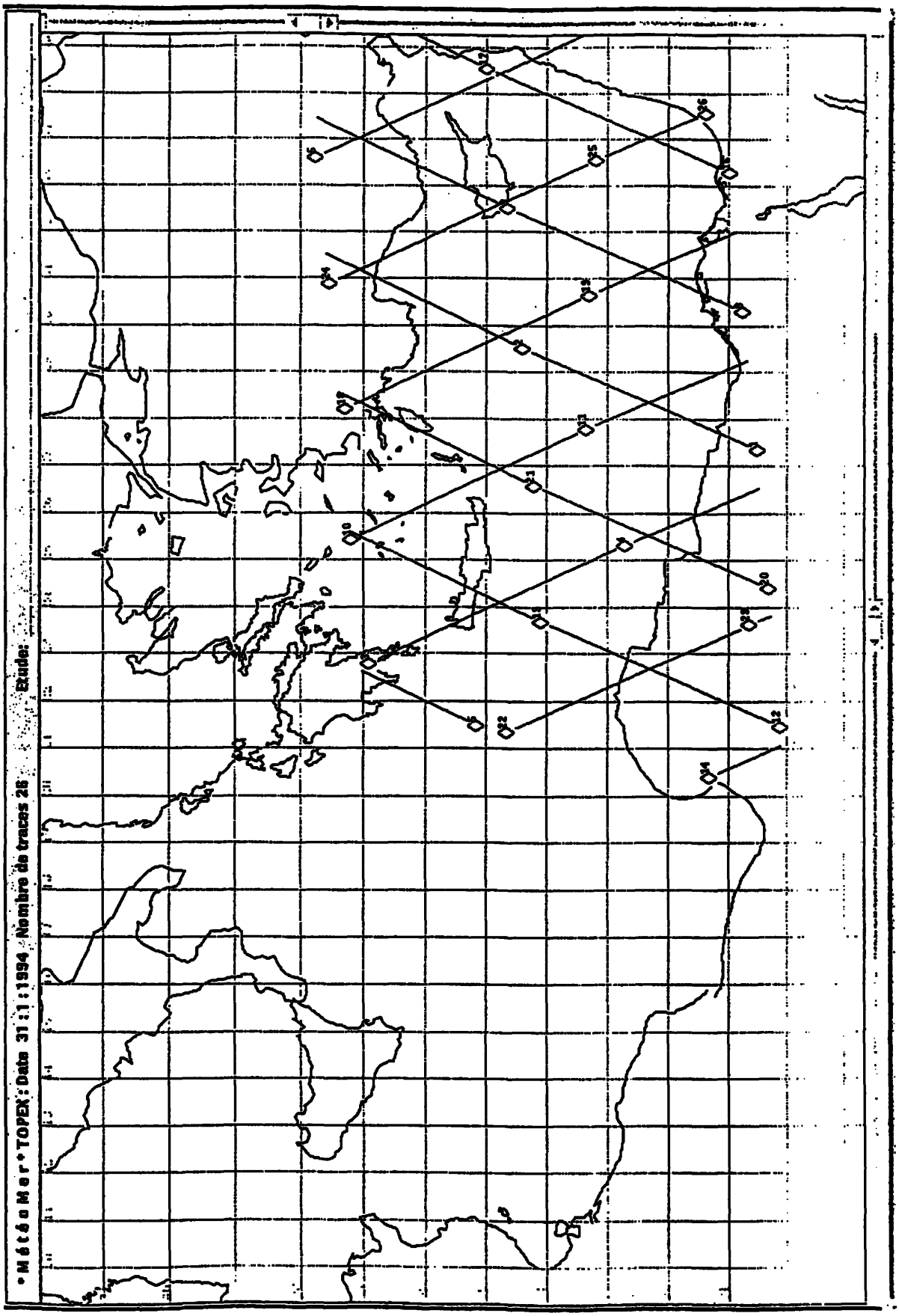


Figure 18. Example of ground tracks relevant to a 10-day repeat cycle of Topex-Poseidon (ascending and descending orbit).

ranges similar to those of field measurements, and particularly, in storm conditions which is a prerequisite for extreme prediction purpose.
As for wind intensities (ff), comparisons with buoy data have led (for Geosat, ERS1 and Topex-Poseidon measurements) to the following respective accuracy : 2m/s, 1.5m/s and 2m/s. Altimeter wind intensities are similar to those computed with metocean models, and correspond to the standard winds averaged on a 10 minute duration, and at a 10 m level.

Active Microwave Instrument (AMI)

ERS 1 and 2 carry the Active Microwave Instrument which combines two separate radars: the SAR and the Wind Scatterometer which provide three operation modes:

- SAR in Image mode

In Image mode, the SAR obtains strips of high-resolution imagery, 100 km width, to the right of the satellite track. The 10 m long antenna, aligned parallel to the flight track, directs a narrow radar beam onto the earth's surface over the swath. Imagery is built up from the time delay and strength of the return signals which depend primarily on the roughness and dielectric properties of the surface and its range from the satellite. Power considerations limit SAR Image Mode operation to a maximum of 12 minutes per orbit, while this also excludes the operation of all other AMI modes. The images are acquired within the reception zones of suitably equipped ground stations.
In Figure 19 is shown an example of ERS SAR image (8 June 1995).

- SAR in Wave Mode

Wave mode operation of the SAR measures the changes in radar reflectivity of the sea surface due to the surface waves (direction and length) in small images (5 km × 5 km) at intervals of 200 km along track. To retrieve the ocean spectrum, an ocean-SAR inversion is used. It consists of finding an ocean wave spectrum in accordance with the observed SAR-image spectrum (Bitner-Gregersen et al., 1995). The application of a so-called "inversion" process allows the transformation of this image spectrum into a common practice engineering directional wave height spectrum. Due to its instrumental characteristics, ERS1 SAR in wave mode measurements show some limitations, in particular:

- wavelengths under 90m (for ERS1) cannot be detected by the radar;
- wavelengths under 150m are more or less attenuated around the flight direction.

As a matter of fact, closed seas are mainly characterised by short waves which most of the time are below the SAR resolution. Thus, SAR mainly offers a determination of the swell component(s) of a sea-state or wind modes for particularly storm events.
In Figure 20 is shown an example of SAR in wave mode product acquired in a point near the Israeli coastline. The representation of the power spectrum is in polar co-ordinates. The nominal wavelengths are 100, 123, 152, 187, 231, 285, 351, 433, 534, 658, 811 and 1000 meters which correspond approximately to the periods 8, 9, 10, 11, 12, 14, 15, 17, 19, 21, 23 and 25 seconds. The sector resolution is 15°. The spectrum shows a 180° ambiguity in direction.

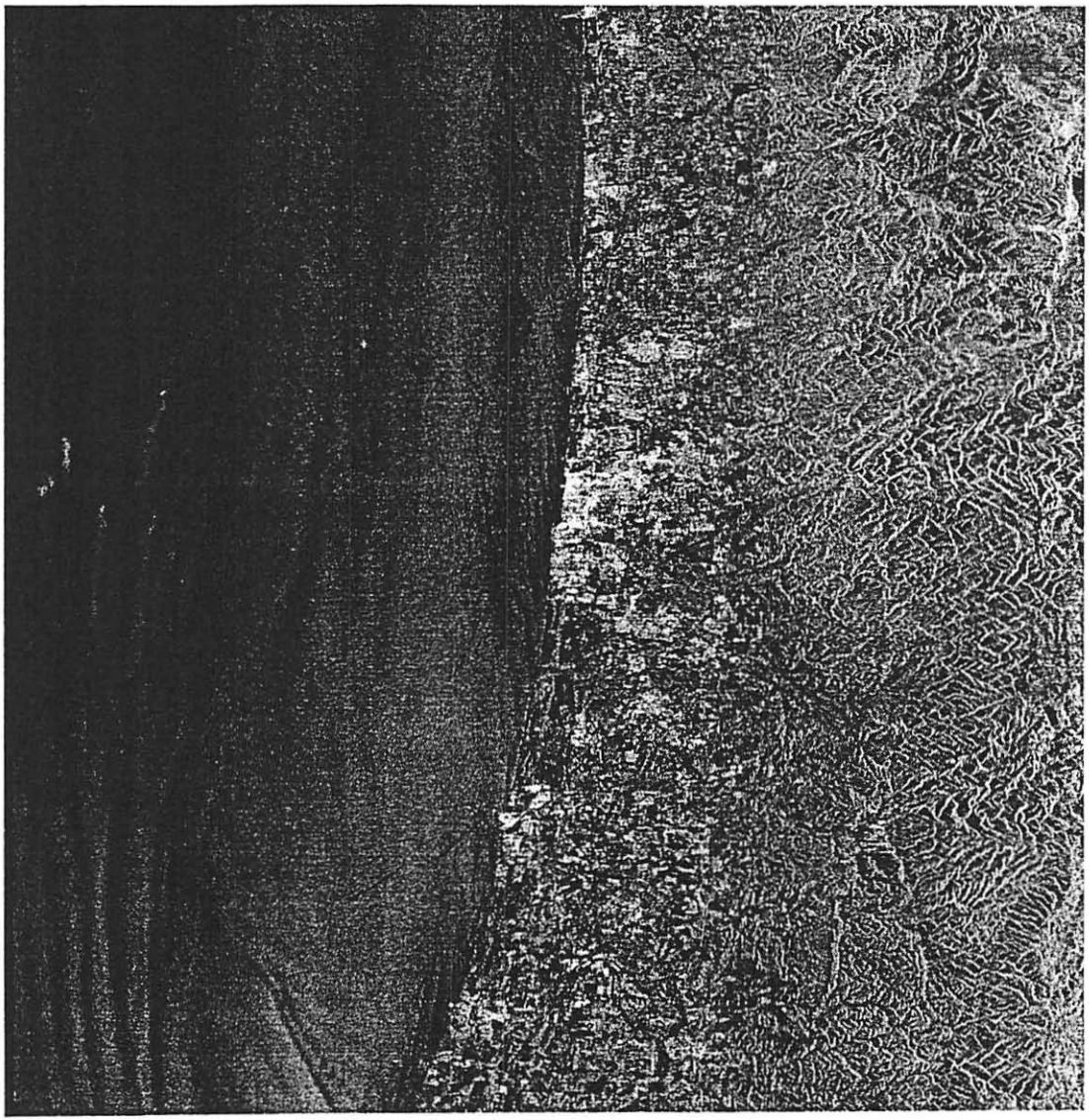


Figure 19. Example of ERS SAR image (8 June 1995).

Figure 20. Example of SAR in wave mode product

- ERS Wind Scatterometer Mode

The ERS scatterometer operating at the C-band frequency of 5.3 GHz (wavelength 5.7 cm) is an active microwave radar. It uses three sideways looking antennae; one pointing normal to the satellite flight path, one pointing 45° forward and the third one pointing 45° backward. The radar illuminates a 500 km wide swath with incidence angles ranging from 18° to 57°. Radar measurements are sampled on a 25 km squared grid. The result is three independent backscatter measurements relating to cell centre nodes, which have been obtained using the three viewing directions and are separated by only a very short time delay.
The principal backscattering mechanism for the scatterometer measurements is the Brag mechanism. The Normalised Radar Cross Section (NRCS) is related to the sea surface wave density spectrum in the wavelength range $L = \lambda/(2\sin\theta)$ where λ is the radar wavelength and θ is the incidence angle. Higher is the wind speed, higher is the wave density in that range and higher are the NRCS values. The NRCS dependency on the wind speed is modulated with the wind direction with respect to the beam azimuth angle.

The so-called "triplets" are then processed to compute the wind vector (speed and direction) using a mathematical model which defines the relationship between backscatter, wind speed, wind direction and incidence angle of the observation. This model is used for all radar-wind scatterometers and is based on empirical calibration. The experience with Seasat, of relating radar backscatter to surface winds and wind stress, showed the necessity for human intervention in calibrating the retrieval algorithm.

1) The ERS C-Band model:
Results of campaigns led by the European Space Agency (ESA) have been analysed by Long (1985). The empirical model relating σ_0 to the wind vector is described by the equation:

$$\sigma_0 = 10^{b0}(1+b_1\cos 2\varphi + b_2\cos 2\varphi)$$

where: $b_0 = a+b(V-\delta)^{1/2}$
$\theta = (\theta_i-36)/19$
$\varphi = \phi-\Psi$

a, b and δ are arrangements of polynomials of order up to three in θ, b_1 and b_2 are arrangements of polynomials of order up to two in θ and V. θ_i is the incidence angle, V is the wind speed, ϕ is the wind direction and Ψ is the antenna azimuth angle.

2) The CERSAT algorithm:
The CERSAT (French Processing and Archiving Facility, Brest) has devoted a considerable effort in developing an efficient software to process the scatterometer data and evaluate the influence of different factors (e.g. noise, bias, model function errors) on the accuracy of the results. This is achieved particularly by validating the ERS C-Band model against an independent database of NOAA (National Oceanic and Atmospheric Administration) buoy data (Quilfen and Bentamy, 1994).

Scatterometer wind intensities and directions are similar to those computed with metocean models, and correspond to the standard winds averaged on a 10 minute duration, and at a 10 meter level.
Comparisons with buoy data have led for ERS1 scatterometer wind intensities and directions to the respective accuracy: 1.2m/s and 15°.

As for coastal areas, the measurements of intensities and directions are often disturbed. Thus, the processing phase is more complex and the resulting wind database has to be studied carefully.
In this case the SAR image can supply accurate wind information which could be very useful for coastal transfer.
Figure 21 shows an example of scatterometer wind measurements. Each wind vector is represented by a vector indicating the direction from which the wind blows and feathers giving the intensity.

Figure 22 shows how a combination of 3 ERS instruments (altimeter, SAR scatterometer, SAR in Wave Mode) could be used for monitoring a storm event. In this case, the histogram relevant to the altimeter data are presented for a full track including 77 values of Hs (vertical bars) and ff (graph).The power spectrum is presented for SAR in wave mode, it shows 2 peaks (9 and 12 seconds) in West-East axis. As a matter of fact, most of the time, in closed/semi-closed seas, local wind is sufficiently strong enough to remove SAR ambiguity.

Bathymetry assessment

As for bathymetry assessment, six ERS Synthetic Aperture Radar (SAR) images have been acquired. The acquisition dates of the six images are listed in Table 7.

Platform	orbit	frame	date	time (GMT)	scene	centre
ERS-1	18336	0639	January 16, 1995	20:00	035.08.24 E	032.20.60 N
ERS-1	19118	2961	March 12, 1995	08:18	035.04.48 E	032.01.48 N
ERS-1	19877	2961	May 04, 1995	08:19	034.44.24 E	032.01.12 N
ERS-1	20378	2961	June 08, 1995	08:20	034.44.24 E	032.01.48 N
ERS-1	20872	0639	July 12, 1995	20:03	034.33.21 E	031.54.04 N
ERS-1	22604	0639	November 10, 1995	20:00	035.10.12 E	032.18.36 N

Table 7. Acquisition dates of ERS SAR imagery for bathymetry assessment.

The nominal resolution of the ERS SAR images is 30.0 m in both ground range and azimuth direction. The line and pixel spacing is 12.5 m. Each SAR image covers an area of 100 km x 100 km. The ERS radar system operates at a frequency of 5.3 GHz (wavelength: 5.65 cm) in VV polarisation mode. The mid-swath incidence angle is 23.5 degrees.

The ERS SAR images are projected on a UTM (Universal Transverse Mercator) co-ordinate system, using the WGS-84 reference ellipsoid

sea state condition

In order to provide offshore and nearshore directional wave height spectra and tools for analysis and extrapolation of environmental databases, satellite data and meteocean deterministic models have been used.

The main steps of these procedures are:
- construction of offshore sea-state and wind databases
- achievement of the coastal transfer of the offshore sea-state databases
- processing of the resulting simultaneous wind and sea-state databases

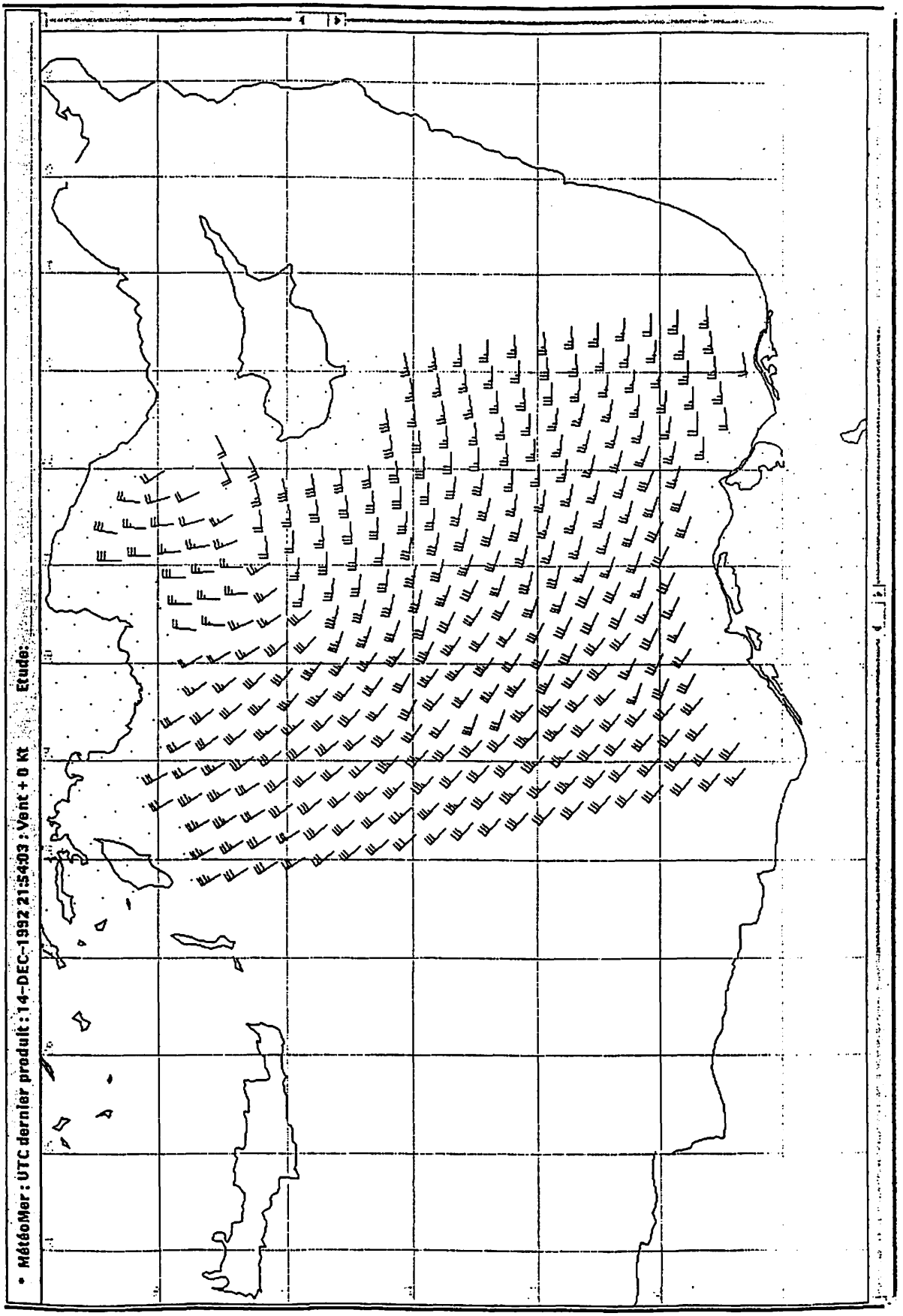


Figure 21. Example of ERS scatterometer wind measurements.

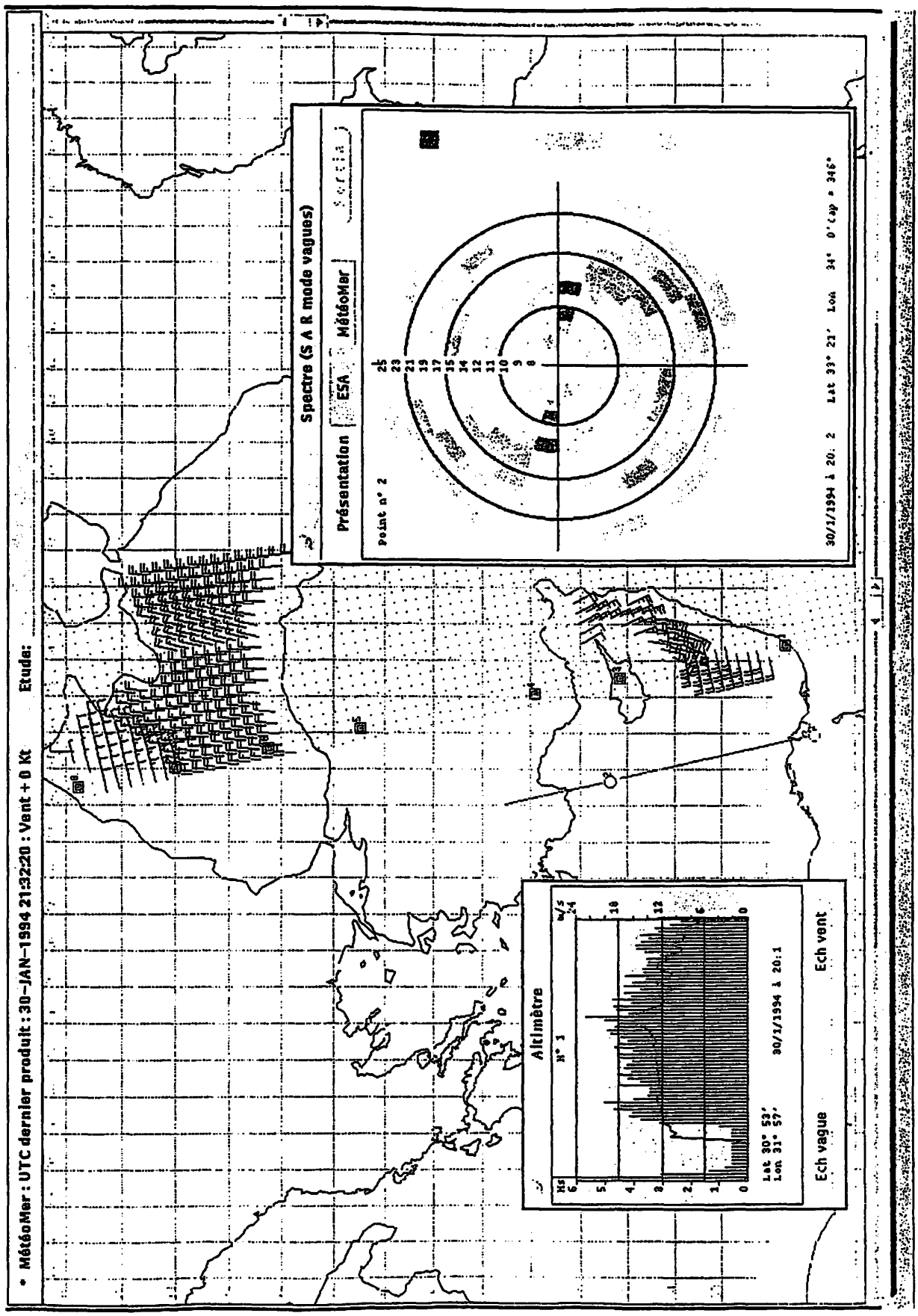


Figure 22. Example of combination of ERS instrument (altimeter, scatterometer, SAR wave mode) for monitoring a storm event.

- comparison to satellite (SAR images) and in-situ measurements (wave measurements): calibration and validation.

The used satellite data are relevant to:
- Hs (significant wave height) measurements by altimeter of Geosat, Topex-poseidon, ERS (1986-1997)
- wind intensity measurement by Geosat, Topex-poseidon, ERS (1986-1997)
- wind direction and period by ERS scatterometer (December 1991- March 1997)
- wave direction and period by SAR in mode wave (December 1991- March 1997)
- 2 SAR images

In the following table are reported the characteristics of these 2 SAR in image mode:

Platform	orbit	frame	date	time (GMT)	scene centre	
ERS-1	18336	0639	January 16,1995	20:00	035.08.24 E	032.20.60 N
ERS-1	22604	0639	November 10, 95	20:00	034.44.24 E	032.01.12 N

Table 8. Acquisition dates of ERS SAR imagery for sea state condition analysis.

5.3.6 Hydro-meteorological information

For a correct interpretation of the remote sensing imagery it is essential to have a basic knowledge of the conditions existing during image recording. Those conditions are listed in Table 9 - if known. Wind information is collected at 10 m above the sea level. Flow information is measured at 12.0 m below sea level.

Platform	Date	time (GMT)	wind speed [m/s]	wind direction [degrees]	flow velocity [cm/s]	flow direction [degrees]	sea level [cm]	wave height [m]	wave height [m]
ERS-1	January 16, 1995	20:00	10.						
ERS-1	March 12, 1995	08:18	3.0	330	10.8	202	-1.40	0.43	0.54
ERS-1	May 04, 1995	08:19	2.9	325	7.2	209	+7.92	0.71	0.55
LANDSAT TM	June 08, 1995	07:23	3.0	301	7.0	9	+2.32	0.29	0.35
ERS-1	June 08, 1995	08:20	2.8	320	7.1	26	-0.25	0.28	0.36
ERS-1	July 12, 1995	20:03	2.0	220	6.8	289	+2.70	0.71	0.99
ERS-1	November 10, 1995	20:00	8.						

Table 9. Hydrometeorological information in connection with the acquisition period of some satellite imagery.

Almost all information reported in this table is relevant to Hadera, except for

i) the wind information relevant to January 16 and November 10, 1995 which is derived from synoptic ECMWF wind field charts;

ii) the wave height information in the last column refers to Ashdod.

As for the CASI imagery recorded on April 18, 1997, the following information is available:

- weather conditions: 0 cloud cover, calm sea
- visibility: 100 km.

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ANNEX 1: Thematic information

List of thematic cover

cover name	*subject*	*item*
tm8 (poly)	national parks & nature reserves	tm8_type
tm22 (poly)	forests	symbol
indst (poly)	industry sites	site
tm14 (poly)	quarrying and mining	l_type
		shalav
		hafaka1
waste (point)	waste disposal	status
tm16 (point)	waste disposal sites	site
river (line)	rivers channels	source
built (poly)	built areas	cit-id
sett (point)	settlements	zurat_yeshuv
set_main (point)	main settlements (>25,000)	* without filtering !
roads (line)	roads	road_type
tm13_use (poly)	coastal data (land use)	use
tm13_roa (line)	coastal data (roads)	comm
tm13_scp (line)	coastal data (landscape)	scape
tm13_off (line)	coastal data (offshore sites)	offshore
tm13_riv (point)	coastal data (river outlets)	none
tm13_bor (line)	coastal data (planned borders)	none
tm13_lin (line)	coastal data (shoreline)	none
tm13_arc (point)	coastal data (archeology)	arch
final_un (poly)	landscape units	sensitivity
		type
lit_bon (poly)	"Habonim" coast - lithology	tashtit_co
veg_bon (poly)	"Habonim" coast - vegetation	veg_code
		rare1
		rare2
		rare_num
		natur_val
lit_ash (poly)	"Ashdod" coast - lithology	number

Data Description

1. National parks & nature reserves (**cover name : tm8.e00** (poly))
   subject : NOS (National Master Plan) No. 8 for National Parks, Nature Reserves and Scenic Reserves
   source scale : 1: 100,000
   last updating date : 21 AUG. 1995
   codification: 1 declared nature reserve
   2,3 proposed nature reserve
   4 declared national park
   5,6 proposed national park
   7 scenic reserve
   8 none

2. Forests (cover name : tm22.e00 (poly)

subject : NOS 22 for Forests and Afforestration
source scale : 1: 50,000
last updating date : 23 JUL. 1996
codification: 2 planted forest (existing)
1 planted forest (proposed)
7 natural forest (for conservation)
3 natural forest (for care)
8 park forest (existing)
4 park forest (proposed)
5 coastal park forest
6 plantings on fluvial channels banks
101 none

3. Industy sites (cover name : indst.e00 (poly))

subject : Land reserves for industry
source scale : 1:50,000
last updating date : 20 FEB. 1996
codification: 1 site
0 none

4. Quarrying and mining (cover: name : tm14.e00 (poly))

subject : NOS no. 14 for Quarrying and Mining
source scale : 1:50,000
last updating date : 3 DEC 1996
codif1: 0 influenced buffer area

a) Hafaka1 area

codification: 0 none
3 limestone
3.1 limestone for cement
5 dolomite
7 sand
8 clay
9 gravel
10 kurkar
13 marble
17 limestone + lime

b) Shalav area

codification: 0 none
1.1 partial active
1.2 will be active in the years 1996-2006
2 will be active in the years 2006-2016
3 will be active in the years 2016-2020
4 exists quarry.

5. Waste disposal status (cover name : waste.e00 (point))

subject : Waste Disposal Sites
last updating date : 2 Jun. 1997
codification: 1 existing solid waste site (approved in national master plan)
2 planned solid waste disposal site (approved in national master plan)
3 existing waste disposal site (not approved in national master plan)

4 confirmed sorting site
5 planned sorting site
6 planned emergency waste site
7 dump site (not approved)
8 existing transfer station
9 planned transfer station
10 closed dump site
11 iron site
12 existing waste site for building material
13 closed waste site for building material
14 closed transfer station
15 confirmed waste site for building material
(16 , 17, 18 missing data)

6. Waste disposal sites (cover name : tm16.e00 (point))
subject : NOS No. 16 for Waste Disposal Sites
source scale : 1:50,000
last updating date : 21 Aug. 1995
codification: emergency - disposal site in an emergency
existing - an existing central or local disposal site
hazard_o - an existing hazard waste disposal site
hazard_p - planned hazard waste disposal site
planned - planned local or central waste disposal site
temp - temporary waste disposal site
treat_0 - open waste treatment site
treat_p - planned waste treatment site
closed - closed central or local waste disposal site

7. River channels **(cover name : river.e00 (line))**
subject : rivers
source scale : 1:50,000
last updating date : 30 Jun. 1996
codification: 0 tributaries
1 main river

8. Built-up areas **(cover name : built.e00 (poly))**
subject : disturbed and/or built up areas (not open areas)
source scale : 1:50,000
last updating date : 28 May 1996
codification : 0 none
>0 disturbed

9. Settlements **(cover name : sett.e00 (point))**
subject : settlements
last updating date : 27 Aug. 1995
Name: zurat_yeshuv
codification: missing data
name : ukh_hakol
codification: total number of population
name : name
codification: Hebrew name in English letters

10. Main settlements (cover name : set_main.e00 (point))

subject :> 25,000 population settlement

11. Roads **(cover name : roads.e00 (line))**
subject : roads
source scale : 1:100,000
last updating date : 15 May 1996
codification: 1 - main road

12. Landuse **(cover name : tm13_use.e00 (poly))**
subject : NOS No.13 for Mediterranean coast - land use
source scale : 1:10,000
last updating date : 18 Sep. 1996
codification: 1 urban settlement
2 rural settlement
3 public institution
4 tourism and recreation
5 industrial
6 infrastructure
7 swimming beach
8 public open space
9 private open space
10 nature reserves
11 national park
12 landscape reserve
13 fishponds
15 railway
16 agriculture
17 offshore swimming
18 marina
19 marine reserve
21 offshore infrastructure
22 Airport

13. Roads **(coastal data) (cover name : tm13_roa.e00 (line))**
subject : NOS No.13 for Mediterranean coast - roads
source scale : 1:10,000
last updating date : 19 Sep. 1996
codification: 1 road
2 railway
3 pedestrian way

14. Landscape value (coastal data) **(cover name : tm13_scp.e00 (line))**
subject : NOS No.13 for Mediterranean coast - landscape values
source scale : 1:10,000
last updating date : 18 Sep. 1996
codification: 1 landscape values
2 antiquities and landscape value
3 natural and landscape value

15. Offshore sites **(cover name : tm13_off.e00 (line))**
subject : NOS No.13 for Mediterranean coast - offshore sites
source scale : 1:10,000
last updating date : 17 Sep. 1996

codification: 1 no offshore structures
2 limited offshore structures
3 permitted offshore structures

16. River outlets **(cover name : tm13_riv.e00 (point))**
subject : NOS No.13 for Mediterranean coast - river outlets
source scale : 1:10,000
last updating date : 17 Sep. 1996

17. Planned borders **(cover name : tm13_bor.e00 (line))**
subject : NOS No.13 for Mediterranean coast - planned borders
source scale : 1:10,000
last updating date : 18 Sep. 1996

18. Shoreline **(cover name : tm13_lin.e00 (line))**
subject : NOS No.13 for Mediterranean coast - shore line
source scale : 1:10,000
last updating date : 19 Sep. 1996

19. Archeology sites **(cover name : tm13_arc.e00 (point))**
subject : NOS No.13 for Mediterranean coast - archaeology sites
source scale : 1:10,000
last updating date : 19 Sep. 1996
codification : 1 antiquities
2 antiquities and natural value
3 antiquities and landscape value

20. Landscape Units **(cover name : final_un.e00 (poly))**
subject :Landscape units relevant to sensitivity
source scale : 1:250,000
last updating date: 1997
sensitivity
codification: 0 not classified
1 extremely high sensitivity
2 very high sensitivity
3 high sensitivity
4 medium sensitivity
5 medium-low sensitivity
6 low sensitivity
type
codification: 1 mountains - hard limestone
2 chalk hills and marl hills
3 basalt
4 kurkar hills
5 sands
6 hamra soils
7 closed valleys (without outlets)
8 alluvial valleys
9 loess and clay plains
10 loess badlands

Lithological and vegetational maps at 1:10.000 scale produced by the Society for Protection of Nature in Israel (SPNI) on two specific areas (Habonim and Ashdod).

21. Lithological map of Habonin coast (**cover name: lit_bon.e00 (poly))**
subject: lithological map of "Habonin" Coast.
source scale : 1:10,000
last updating date: 1 Dec. 1996
codification: 1 sand
2 kurkar
3 kurkar + sand
4 beach rock
5 shells
6 pebbles
7 stabilized sand / half stabilized sand / half stabilized sand + shale.
8 kurkar + shale / kurkar + sand + shale.
9 alluvium / shale
10 fluvial channel
13 wreck

22. Vegetation map of Habonin coast **(cover name: veg_bon.e00 (poly))**
subject: vegetation map of "Habonin" Coast.
source scale : 1:10,000.
last updating date: 4 Oct. 1997
veg_codification:codes for various botanical species.
first rare plant in every veg_unit: codes for various botanical species.
second rare plant in every veg_unit: codes for various botanical species
rare_num (count(rare1)+count(rare2))
codification: 0
1
2
natural value index
codification: 1 low
2 middle
3 high
4 very high
5 especially high
6 non vegetated unit

23. Lithological map of Ashdod coast **(cover name: lit_ash.e00 (poly))**
subject: lithological map of "Ashdod" coast.
source scale: 1:10,000
last updating date: 5 May 1997
codification: 11 tide and depression coastal zone
12 sandy beach
21 bare kurkar
22 sand lobes on kurkar ridge
23 colored sands on kurkar ridge
31 high sand dunes
32 medium dunes and colored sands
33 depressions in the sands
34 sand sea

41 various plants
42 various plants
43 various plants
50 quarries and earth mounds or trenches
60 unmapped polygons
61 settlement
62 kurkar outside mapping borders:
99 unknown units

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