

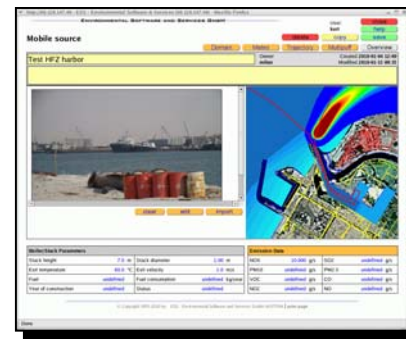
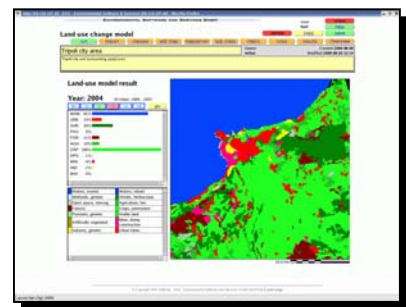
CoastWare: ICZM, biodiversity and coastal ecology

Version: March 2011

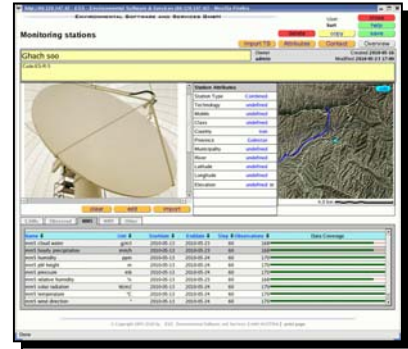
Scope and functionality:

CoastWare is a state-of-the-art web based solution for the (integrated) environmental planning and management of the coastal zone, within an ICZM (Integrated Coastal Zone Management) within a logical framework that combines ICZM, EIA/SEA, DPSIR (driving forces, pressures, state, impact response) ISO 14000. The system integrates software tools, data and knowledge bases for Coastal Zone biodiversity and ecological studies: www.ess.co.at/ICZM/tools.html. Problems and tasks within an ICZM framework include:

- **Regional coastal development planning**, land use dynamics, economic development and related resource use, aquatic and atmospheric emissions. WELLM analysis considers water energy, land, manpower and material for scenario analysis and long-term projections.
- **Environmental and strategic impact assessment** for any such development projects; typical examples are urban development including water front development, dredging or artificial islands, harbors with or without associated industrial zones, large individual industries in coastal locations, off-shore installations (mainly from the petrochemical industry, mining) coastal fishery (from development to restrictions) and aqua-farming, tourism, or environmental protection, marine parks and nature reserves.
- **Baseline studies**, mapping of physiographical, ecological and biological (biodiversity) data as a baseline for both impact assessment and monitoring of trends and developments;
- **Vulnerability studies**, addressing endangered species including coral, and the identification of threats, e.g., from coastal development; examples of typical **stressors** include wastewater outfalls from urban or industrial sources, with or without wastewater treatment; cooling water from thermal power stations; brine from desalination plants; structural/morphological changes to the coastline that affect flows, coastal erosion and sediment accretion; any (industrial or transportation) activity that may lead to accidental spills of hazardous material, oil spills being the most common case;

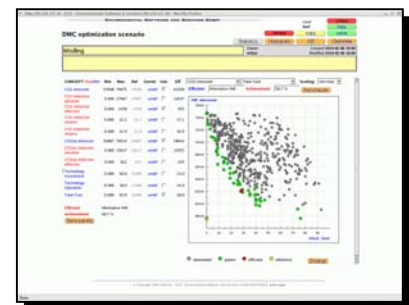
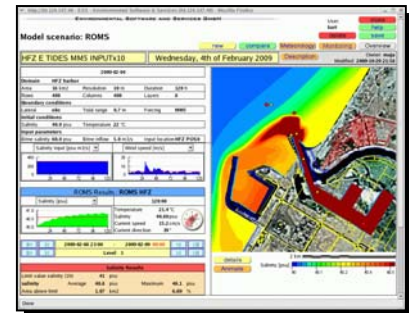
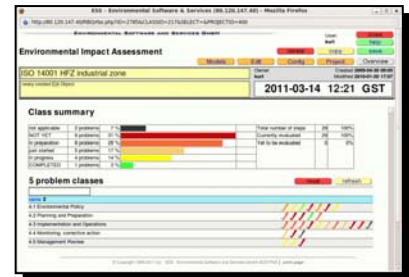


- **Simulation studies** for predicting the impacts of existing or planned urban and industrial development projects on the coastal environment;
- **Continuous monitoring** (with or without simulation) for the identification of trends and as early warning systems in case of accidental spills;
- **Long-term strategic monitoring** projects that address climate change impacts, both in terms of water temperature and associated biological stress; sea level rise, increased frequency and severity of storms and wave action, and their impacts on coastal erosion.



The associated ICT tools and analytical methods including components of applied AI (Artificial Intelligence) to manage the data and support these problems include:

- **Information systems:** data bases and GIS with the associated tools for data analysis, including dedicated editors and data processing tools for bathymetry; data bases are geo-referenced, and provide a multi-media display of the data combining, text, numbers, and imagery, as a prerequisite and guidance for any field data surveys.
- **Meteorological simulation:** operational forecasts and scenario analysis that generates meteorological inputs to atmospheric dispersion and coastal flow and transport, sediment and wave models; 3D non-hydrostatic model MM5 or WRF are run with NCEP FNL (historical re-analysis) or GFS (operational forecasts) data, hourly and 1 km resolution;
- **Oceanographic models** (3D ROMS) for the simulation of physical and biological marine parameters; the Regional Ocean Modeling System is used for flow and transport modeling, dispersion of pollutants, sediment interaction (erosion transport, sedimentation), biological processes, and as the basis for oil spill modeling;
- **Impact assessment:** rule-based expert system for screening level EIA/SEA, based on ISO1400 principles; hierarchical (intelligent, problem and context specific) checklists are used to guide the analysis in a dialog (backward chaining inference) for the assessment of potential problems;
- **Dynamic land use simulation** modeling for long-term predictions of land use/land cover changes; a dynamic state-transition model based on dynamic external driving forces including policy, zoning, master plans, regulatory



guidelines, *a-priori* transition probabilities and first-order production rules that can modify the primary transition rules and probabilities.

- **DSS: discrete multi-criteria decision support** tools for ranking and selection of alternatives, based on user-defined indicators and indices (KPI, EPI). Alternative solutions from scenario analysis are compared and, ranked by one or more criteria to find a compromise solution and trade-off between competing objectives, also supports a multi-user participatory approach.

The basic objective is to design, implement, and populate a data and knowledge base and associated analytical tools for coastal ecology and biodiversity that is complete and consistent, provides a reliable baseline (state-of-the-coastal-environment), and a starting point for the monitoring, management and protection of the coastal zone and its ecological resources and biodiversity.

CoastWare addresses and supports:

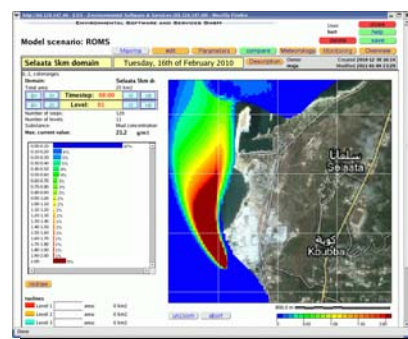
- **Coastal environmental baseline data** bases and cartography (GIS), including data compilation, processing and analysis for physiographical and biological/ecological data including species data base, distribution and density, environmental stressors, vulnerability analysis, sources of pollution and external pressures, land use/land cover, development, zoning and master plans.
- **Habitat (ecosystem) classification, biodiversity**, ecological data, derived from
 - desk studies for the identification and analysis of available data;
 - remote sensing (high resolution multi-platform satellite imagery and aerial photography, mapping and analysis;
 - detailed field surveys (terrestrial and marine) at selected locations of special interest based on the remote sensing data analysis;
- **Model based scenario analysis** for environmental/ecological processes, including coastal meteorology and oceanography, water quality, flow and transport, currents and wave action, sediment erosion and transport, pollutant emissions and dispersion, ecosystem (habitat, fauna, vegetation and land cover) dynamics;
- **EIA/SEA**: Environmental and Strategic Environmental Impact Assessment: a rule-based expert system with embedded simulation models for the assessment (compliance monitoring) of coastal development projects, in conjunction with the associated user/operator training.

System components and models

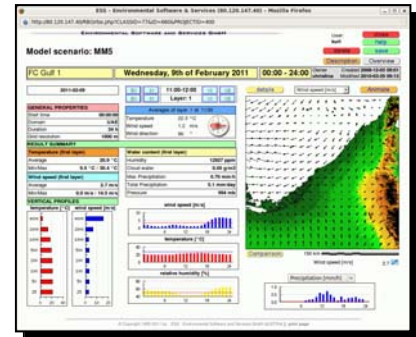
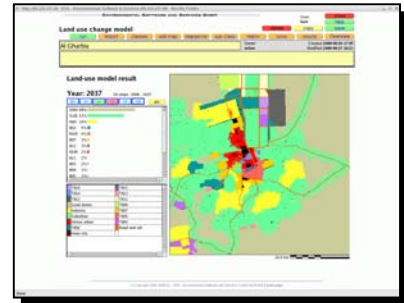
CoastWare combines data bases, GIS, monitoring data management, and several simulation models for interactive analysis, see also:

<http://www.ess.co.at/ICZM/tools.html>

- **ROMS**, 3D oceanographic model system for flow and transport (MM5 derived surface forcings) sediment interaction, several pollutants, biological



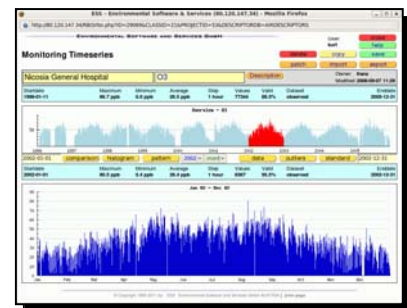
- processes, oil spills, coupled with wave modeling (e.g., SWAN)
- **LUC** Land use/land cover and habitat dynamics, a stochastic state transition model (Markov chain and first order rules) for long-term projections;
 - **EIAxpert** a rule based expert system for screening level EIA/SEA that can integrate simulation models to estimate environmental impacts.
 - **MM5**, the fifth generation Penn State/NCAR meso-scale model, a non-hydrostatic, 3D dynamic nested grid meteorological forecasting model
 - **Air quality models** including **CAM**, an Eulerian photochemical dispersion model (Ozone, PM-2.5, PM-10, air toxics, mercury) over many scales from sub-urban to regional, **AERMOD** represents the latest of USEPA’s regulatory dispersion models, derived from the ISC family of models, based on more current planetary boundary layer (PBL) parameterizations.



Monitoring data integration

The data bases include capture and analysis of real-time or near real-time monitoring data (meteorology, oceanography, air and water quality, emissions); monitoring data can be used for

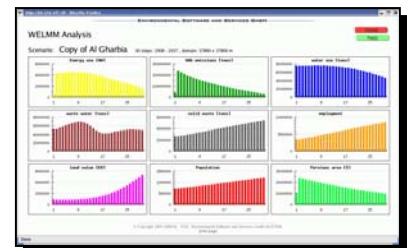
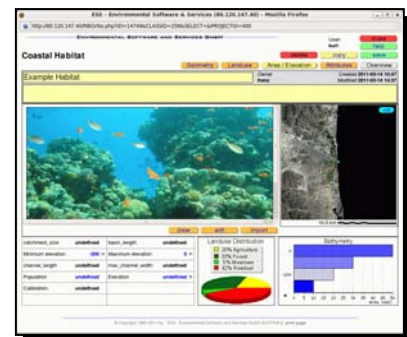
- compliance analysis: monitoring cum modeling for high-resolution spatial coverage
- model inputs (now-casts, scenarios)
- real-time data assimilation (nudging of initial conditions)
- model calibration and validation.



Support functions

CoastWare includes a range of support function and tools including:

- Indicator definition (multi-criteria, KPI, EPI), tracking and prediction;
- Long-term (multi-annual) scenario analysis for EIA studies;
- Multi-criteria (techno/economic) optimization of emission control strategies, optimal location of monitoring stations
- Embedded GIS, MapServer
- Knowledge Base editor for the embedded rule-based expert system for automated QA/QC functions



- User management and (web) access control
- System log data base for all scheduled processes for remote diagnostics
- Data base maintenance, backup (USB disks, optional remote off-site backup)
- Integrated hypertext help- and explain pages and user manuals and tutorials
- A problem-reporting system to support remote support and maintenance functions
- Automatic synchronisation with an optional remote mirror installation
- Support for 3G mobile clients (SmartPhones).



Remote support and maintenance include the possibility of complete operational mirrors, backup and disaster recovery, computational services for demanding (cluster implementation including meteorological forecasts) or mission critical applications, regular updates, continuing user training, application support as well as related studies and consultancy.

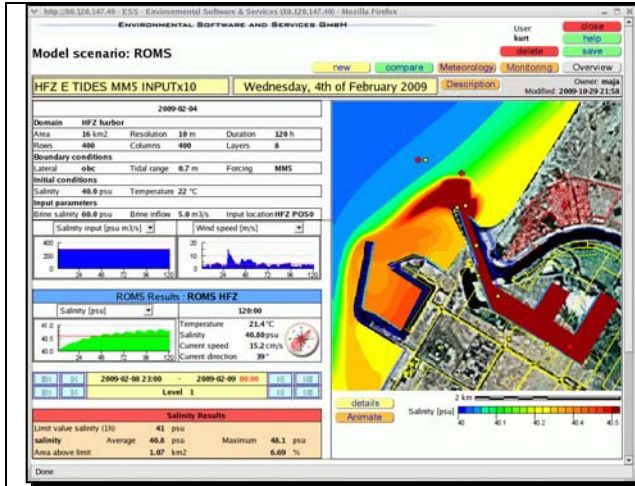
Habitat Classification

Habitat classification as an essential component for biodiversity assessment, mapping, and eventual monitoring is structured according to the generic International Vegetation Classification system (IVC) that provides both consistent unit definition criteria and relationship to systems used globally (Grossman et al., 1998). Ecological Land Classification (ELC) is hierarchically structured, low-resolution aggregate units will be defined by general landform and climactic variables (remote sensing and FNL-based climate modeling) with more local units (habitats) defined by specific geomorphology and benthic/vegetation structure and community (high resolution satellite imagery, aerial photography, ground level field surveys).

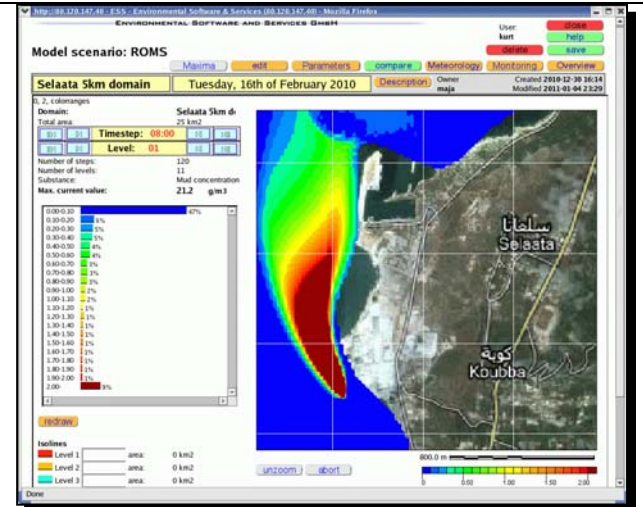
Specific local classification systems will be applied where appropriate, e.g., the habitat types defined in Brown and Böer (2004), specifically appropriate to Abu Dhabi, and Barth and Böer (2002) for Shabkha (coastal salt flat) Ecosystems.

References:

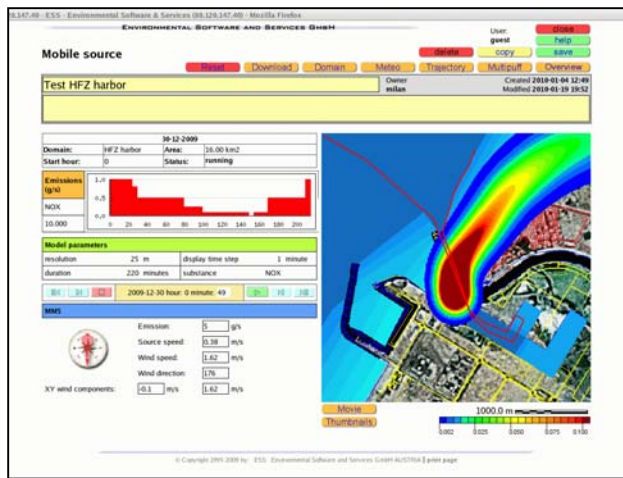
- Barth and Böer (2002)** Sabkha Ecosystems. Vol.I: The Arabian Peninsula and Adjacent Countries. Tasks for Vegetation Science 36, 354 pp, Kluwer, Dordrecht,
- Fedra, K. (2008)** Coastal zone resource management: Tools for a participatory planning and decision making process. 673-686., In: R. Krishnamurthy et. al., [eds]: Integrated Coastal Zone Management - The Global Challenge. Research Publishing Services, Singapore.
- Fedra, K. and Abdel-Rehim, A. (2004)** Spatial Analysis for Coastal Zone Management: Beyond GIS. Proceedings of CoastGIS'03, on-line: <http://www.gisig.it/coastgis/papers/fedra.htm>
- Fedra, K. and Feoli, E. (1998)** GIS Technology and Spatial Analysis in Coastal Zone Management. *EEZ Technology*, Ed. 3, 171-179.
- Goodin, K. (2008)** Coastal and Marine Ecological Classification Standards CMECS), Version III. 76 pp., NatureServe,
- Grossmann et al., (1998)** International Classification of Ecological Communities. Vol.I, The Nature Conservancy, Arlington, VA.



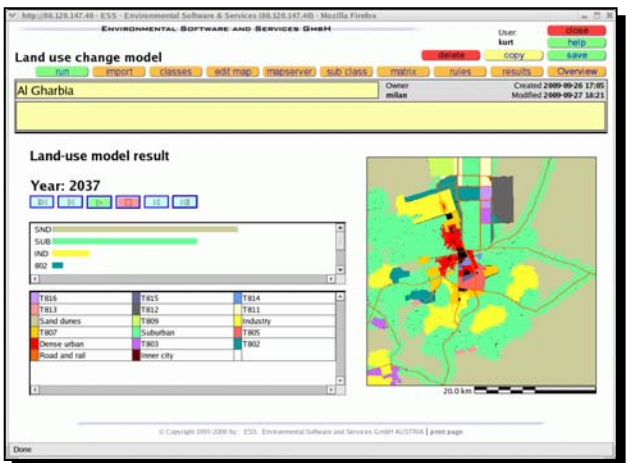
RO plant brine release scenario



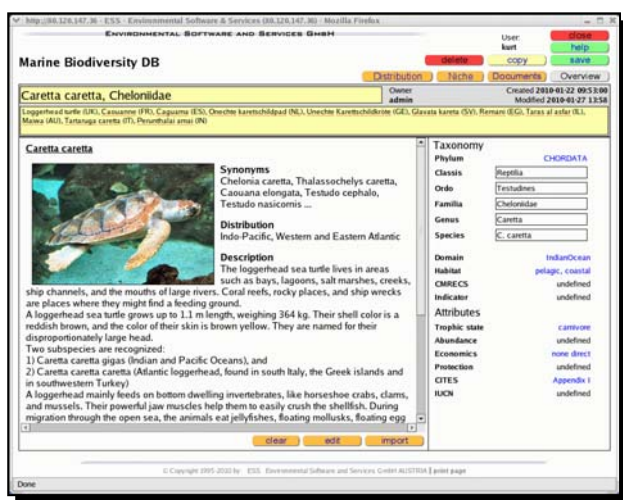
Phosphogypsum sludge release



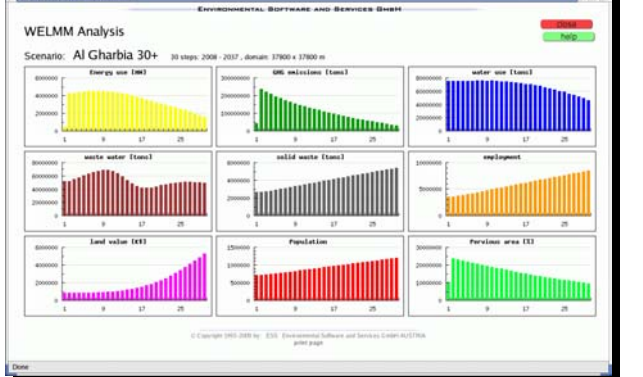
Emission from ships in a harbor



Coastal land use dynamics



Species and biodiversity data base



WELMM analysis, 30 year projections: water, energy, land, manpower, materials