NATO CCMS

CURONIAN LAGOON
JODKRANTE
LITHUANIA
Workshop
Report

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EXECUTIVE SUMMARY

The NATO CCMS (Committee on the Challenges of Modern Society) Study on Ecosystem Modeling Of Coastal Lagoons for Sustainable Management concluded a workshop on the Curonian Lagoon in Juodkrante, Lithuania on May 26, 2004. During the conference three key components of sustainable management of the Curonian Lagoon were evaluated: ecology biogeochemistry, hydrodynamic modeling, and management decision making processes. Recommendations for sustainable use and development of the Lagoon were developed and are contained in this report.

Dr. Ethem Gonenc from Turkey, Director of the Study, stated that the conference was successful for the exchange of opinions and development of recommendations to promote scientifically based resource management on an interjurisdictional / trans-boundary basis between Lithuania and Russia. Dr. Albertas Kvietkus, vice Director of the Curonian Spit National Park, commented that the NATO CCMS International scientific experts were invited to assess existing natural resource problems. Dr. Kvietkus called for increased collaboration with Russia on management of the Curonian Lagoon and greater involvement with European-American scientists.

Over twenty-five scientist represent fourteen countries including Lithuania, Russia, Kazakhstan, Kyrgyz Republic, Azerbaijan, Turkey, Italy, Romania, Spain, Latvia, Germany, and the United States were involved in the workshop.

The NATO CCMS Scientist have been meeting since 1995 with scientists of many countries under the mission of science for peace. It is NATO's intent to enhance stability with programs aimed at establishing and maintaining communications with the scientific elite. The NATO Scientist will be releasing a manuscript entitled: Coastal Lagoons: Ecosystem Processes and Modeling for Sustainable Use and Development in fall 2004. The book is being published by CRC Press, Boca Raton, Florida, USA.

24. 05. 2004/ Juodkrante/ Lithuania
NATO - CCMS workshop

Working group: Ecosystem & Biogeochemistry

- A group of six young (s) and senior (1) scientists from Lithuania & Russia, working on the ecology of Curonia Lagoon, together with two senior scientists belonging to the NATO-CCMS group, have attended the session focused on the evaluation of past and current ecological research approach as well as of the use of accumulated data and information about "biogeochemistry and ecology" of this lagoon for mathematical modelling and adaptative management.

- **Goal:**

Identical with that formulated for a similar session held on 21.05. 2004/ Svetlogorsk/ Russia.

- Findings:

i) a well documented data base concerning the structure and dynamics of fish species assemblage and the dynamics of fish catches.

- A comparative analysis of the trends in the dynamic of populations and catches, on one side and, the dynamics of fish eating bird species and eutrophication, on the other side, has been carried out.
- A consistent data base about the changes in composition and population size of the phytoplankton and zooplankton, established by using data derived from monitoring activities.
- The influence of hydrodinamics and hydrochemistry (in particular nutrient loads) on species composition and abundance of phytoplankton and zooplankton has been investigated in the last 5 years, by designing and implementing appropriate field experiments. This type of activity carried out by young scientists might be considered the starting point for a more comprenhensive and long term research programme focused on understanding and modelling of the ecosystem functioning.
- Based on historical data concerning the composition, abundance and trophic spectrum of dominant species, gas been developed the structural model (network of trophodynamic modules) of the Curonia Lagoon. We stressed that this is the first step for designing a long term monitoring and research of the lagoon system and for development the package of mathematical models which have to serve as tools for adaptative management.

ii)& iii) The statements included in the report for Vistula Lagoon are entirely valid also for Curonia Lagoon.

iv) Accepting that the system identification for Curonia Lagoon is in a advance stage comparing with Vistula Lagoon it, was also stressed that all the other suggestions made for Vistula Lagoon, have to be applied in this case too.

Report on the Curonian Lagoon

The Modeling Group, LEMSM

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Description of the Curonian Lagoon

The Curonian Lagoon is a shallow transitory freshwater basin, connected to the south-eastern Baltic Sea through the narrow Klaipėda strait (Fig. 1). The narrow sandy Curonian spit separates the Curonian lagoon from the Baltic Sea. The lagoon is of triangle shape. The broadest part, up to 46 km wide, is in the south of the lagoon, while in the northern part the width reaches only 550 m. The length from the southern to the northern part is more than 90 km. The area of the lagoon is 1584 km^2 and its mean depth is 3.8 m; while the maximum depth reaches 5.8 m in the southern part and 10-12 m in the artificially deepened Klaipėda Strait harbor area. The southern and central portions of the lagoon contain fresh water due to discharge from the Nemunas River (24 km^3/year) and other smaller rivers, while the salinity in the northern part varies from 0 to 8 psu, depending on wind activity affecting brackish water inflow from the Baltic Sea. The predominant flow of water is from the south to the north discharging approximately 22 km^3 per year into the Baltic Sea. Brackish water intrusions are most common during August to October when 70 % of the total annual salt water inputs occur.

In the Curonian lagoon dominate **sediments** derived mostly from the land. In the middle part the sand and silt coarse predominate, while in the deeper places and in the low hydrodynamic zones the fine-silty and silt-clayey mud occur. In the active wave and current zones the boulders and gravel appears. The similar sediments are in the southeastern and southern part of the lagoon, while in the northern part the fine sand dominate. In some parts peat, mollusk shell or some other type of sediments can be found.

Curonian Lagoon is a **temperate** estuarine lagoon. Therefore, the lowest water temperatures (0.0-0.1°C) occur during the January to February, when the lagoon is covered by the ice. The highest temperatures 25-27°C is observed from July to August. The ice cover lasts approximately 110 days, while during warm winters the continuous ice cover cannot form at all.

Western and Southern **winds** predominate in the lagoon area. Usually winds are not strong, just 1-5 m s^{-1} (55 %). The winds stronger than 15 m s^{-1} occur during autumn through winter. In the lagoon are more frequent wind induced waves *vs.* inertic ones. The waves due to the small depth are short and the wave height is mostly decided by the wind speed.

The annual cycle of the **biogenic** compounds follows the pattern typical for temperate waters. The highest nitrate and phosphate concentrations in Curonian Lagoon ~114.3 and ~6.1 µmol l^{-1} respectively are observed during the winter through early spring. During the summer nutrient concentrations could drop till the analytic zero and remain low until the autumn. Due to fast phosphorus regeneration already during the summer the concentration of phosphates could increase up to 6.5 µmol l^{-1}.

The Curonian Lagoon **phytoplankton** dynamic also follows seasonal pattern typical for temperate freshwaters. Diatoms dominate during the spring. When the temperature rises up to 15-16°C the cyanobacteria appears and after some period they become dominant. Cyanobacteria generally are abundant till the end of September, and some times could be abundant even till October. The green algae usually do not dominate phytoplankton community and are abundant since April to September.

Seasonal succession of freshwater **zooplankton** is characterized by a sequence of dominant species: *Cyclops* spp. in spring until middle of May, *Daphnia* spp. afterwards until middle of July, and *Chydorus sphaericus* onwards. From the middle of September the Cyclopoida starts to dominate again.

About 50 **fish** species live in the Curonian Lagoon including the most common such as: roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), redeye (*Scardinius erythrophalmus*), white bream (*Blicca bjoerkna*) and common bream (*Abramis brama*). The pike (*Esox lucius*), pike-perch (*Lucioperca lucioperca*) and eel (*Anguilla anguilla*) are also present in the lagoon. It is very popular to go for smelt (*Osmerus eperlanus*) in the winter season.

The geography of the Curonian Spit is well suited for scientists studying **bird** migration routes. The White Sea-the Baltic Sea migration "highway" goes along the spit and millions of birds passes it. For this reason the bird-ringing station was set up in Juodkrante.

A mixed colony of grey herons (*Ardea cinerea*) and cormorants (*Phalacrocorax carbo*) settled near Juodkrante. This is one of the largest and oldest colonies in Lithuania. 1361 pair of cormorants and 582 pairs of grey herons hatched there in 2000.

Several rare bird species breed in the national park also. White-tailed eagles (*Haliaëtus albicilla*) build their nests in places where humans hardly ever tread. Two or three pairs of these birds hatch every year. In the woods the black kite (*Milvus Haliaëtus*) and the hobby (*Falco subbuteo*) also have nests.

Data availability for the Curonian Lagoon

Bathymetry data is available good enough to make a fine resolution grid (50-100 m grid cell) for the entire lagoon and the Klaipeda Navigation Canal (20-40 m grid cell).

Russian points of regular hydro-meteorological measurements:

- one point of water level measurements at the south part of the lagoon – at the mouth of the Deima river.
- the closest to the lagoon point of water level measurements in the Nemunas river is situated in town Sovetsk
- the water discharges at these points are calculated on the basis of known hydrographs for these rivers.

Existing monitoring network for water quality in lagoon comprises 6-8 points on the Russian side and 10 points on the Lithuanian side (Fig. 2).

Historical data sets of hydro-meteorological data from coastal stations of the hydro-meteorological system exist for the period from 50th. Data for lagoon water quality is available from 70th.

Capacity of modeling teams

Several computer models for the Curonian Lagoon exist or were used in the past by different institutions in the area:

- In Atlantic Branch of P. P. Shirshov Institute of Oceanology, Russian Academy of Sciences and Kaliningrad Department for Natural Resources and Nature Conservation a scientific finite element model (only hydrodynamic) was used in the 90th to study the principal current patterns in the lagoon.

- MIKE21 in Lithuanian Energy Institute (hydrodynamics, sediment transport) was used for analysis of sediment dynamics in the lagoon inlet.

- ECOPATH model was used to balance steady state matter flows in the trophic network of the Curonian lagoon ecosystem.

- BSHcmod for Lithuanian coastal waters, using data of the regional model for the North and Baltic Seas (known as BSHcmod and closely related to the HIROMB model).

- A finite element model (SHYFEM) developed in collaboration between Klaipeda University and ISMAR-CNR, Italy.

The last two models have shown promissing results and are described further in the following.

A model for coastal Lithuanian waters

The three-dimensional hydrodynamic model was adapted for the Lithuanian marine waters. This model enables one to obtain the time series of the hydrodynamic parameters in the real period of time. By using this model, the analysis of the heterogeneous activity concentration distribution of ^{137}Cs in the Lithuanian waters was performed. The results also enabled one to assess the influence of the Nemunas river on the Lithuanian marine waters.

The circulation patterns in the Curonian Lagoon were analyzed using the hydrodynamic model, and the influence of established circulation patterns on the distribution of the Nemunas river waters, as the potential source of contamination, was analyzed.

Using the hydrodynamic model of the Lithuanian marine waters, real time periods were simulated and the distribution of fresh waters at the Lithuanian coast was studied. The following objectives were met in this study:

- to adapt the circulation model of the Baltic and North Seas (*BSHcmod*) for the Lithuanian marine waters and to perform its validation.

- to analyze the influence of the Nemunas river on the Lithuanian marine waters.

- to assess possible sources of the heterogeneous distribution of activity concentration observed in case of ^{137}Cs.

Results of the model are shown in figures 3 and 4.

A finite element model for the Curonian lagoon (SHYFEM)

The hydrodynamic model used in this work is a two-dimensional finite element model developed at the CNR-ISMAR of Venice (Umgiesser, 1997; Umgiesser and Bergamasco, 1995) and successfully applied to the Venice lagoon. The finite element method gives the possibility to follow faithfully the morphology and the bathymetry of the system and to better

represent the zones where hydrodynamic activity is more interesting and important, like the Nemunas delta and the Klaipeda strait. The model uses finite elements for spatial integration and a semi-implicit algorithm for integration in time. The terms treated implicitly are the divergence terms in the continuity equation and the 2 Coriolis term, the pressure gradient and the bottom friction in the momentum equation; all other terms are treated explicitly. Results of the model application are shown in figures 5 and 6.

Innovative modeling and resolution of physical processes

Progress in understanding of the ecosystem functioning, links between physical, chemical and biological processes is coupled with advances in modern computer tools and techniques. This raises the question of corresponding improvement of operational models and models used for management purposes. These models are supposed to resolve more and more complicated processes, to embrace wider ranges of relationships and to deal with more complex problems.

Several processes in the Curonian and Vistula lagoons were pointed out. For the Vistula lagoon, the water exchange with the Baltic sea should be resolved more accurately and described in terms of inflow/outflow events, with their own (different) mixing features. Additionally, sea water transport upstream the Kaliningrad marine channel has to be taken into account. A sediment re-suspension is of importance for biochemical processes in both the Vistula and Curonian lagoons. Structure, composition and pollution density of bottom sediment must be included in both physical and chemical and biological modeling.

However, model complexity causes difficulties in its use and significant increase of data required for calibration, verification and operation of it. A management practice indicates some ways how to balance these contradictions. Conceptually, there are several ways of possible development of environmental modeling today. Most probably, the future is in the development of systems of linked models, responsible for simulation of more and more fine processes in detail. One methodology, applied already in many such systems, is to develop several separated modules (or models), working one after another, providing the flow of information from background physical processes through simulation of chemical features to biological characteristics. They are rather flexible and can be adapted to both

- very accurate simulation of particular process (or particular small areas) and
- very wide range of (averaged) processes.

An alternative methodology is the development of coupled models, which exchange information after a certain number of time steps. They are also structured as separated modules, calculating different processes, and can be adapted to specific needs by additional programs.

Modern environmental models deal with large water bodies, catchment areas etc., i.e., with large-scale objects. So, not only direct contact measurements, but also remote sensing data can be widely used, especially for large-scale forecast simulations. Various institutions have data banks and services for remote sensing data handling, which display via Internet an information on surface temperature, water level variations, etc.

Similarities and differences between the Vistula and the Curonian Lagoon

Both lagoons are shared by two countries that makes monitoring difficult. Data exchange is also not regulated.

The connection between the Curonian lagoon and the Baltic Sea occurs thought the Klaipeda Strait, which is several kilometers long and has a width of 400 to 800 m. The only Lithuanian port is situated in the Klaipeda Strait and large economically important actives are going on there. Therefore modeling of the Klaipeda Strait is of great importance for the port administration (and Lithuanian authorities). MIKE21 hydrodynamic and transport modules were applied, for example, before performing dredging activities in the Klaipeda Strait.

In case of Vistula Lagoon the port is situated in the lagoon and the port administration is also recognizing the importance of modeling results in a decision making process. The artificial ca. 40 km long channel partly separated from the lagoon by artificial islands and connecting the Baltiysk Strait with the port situated in the mouth of the Pregel River is one of the challenges to model.

MIKE 21 was applied for the Vistula Lagoon, also for Klaipeda Strait. MIKE21 was not applied to the Curonian Lagoon itself. Personal scientific model (on the basis of a finite element approach) was applied to the Curonian Lagoon only for scientific estimation of current structures during western storm (Irina & Boris Chubarenko, 1995).

No operational models in both cases exist. However the Marine institute in Gdansk, Poland, has started setting up the operational model of Vistula lagoon using HIROMB data at the open boundaries and HIRLAM data for forcing. This is not the case for the Curonian Lagoon.

Modeling of the Curonian Lagoon was interesting only for some scientific groups so far. Two models exists:

- the BSHcmod for Lithuanian coastal waters, using data of the regional model for the North and Baltic Seas (known as BSHcmod and closely related to the HIROMB model) and

- SHYFEM finite element model developed in collaboration between Klaipeda University and ISMAR-CNR, Italy.

The similarities of the lagoons are:

- Shallow waters – in average ca. 2.5 – 3.5 m deep, maximum does not exceed 5.5 m.

- One connection to the Baltic Sea – channel 400 m width.

The main basic hydrographic differences which leads to many consequent differences at hydro-chemical and hydro-biological levels are:

- The Curonian lagoon hydrology is completely controlled by river the discharge of the Nemunas rivers, while the Vistula Lagoon is under influences of both water exchange with the Baltic Sea and fresh water flux.

- The Curonian Lagoon is practically fresh and may be considered as a running lake, while the Vistula Lagoon has an intermediate salinity (2-4 psu in average).

Problems

In this section some problems are listed that are specific to the Curonian lagoon and the application of models. These problems concern:

- The Curonian lagoon is a trans-boundary lagoon. Despite already existing agreements on the governmental level more practical steps could be taken. Management at the international level is needed due to trans-boundary status of the Curonian Lagoon.

- The Curonian Lagoon is mostly used for fishery and recreation. However, Klaipeda port situated in the Klaipeda strait carries more diverse functions as well as limited vessel traffic takes place in the Lithuanian part of the lagoon.

- Water quality issues are highly related to the discharges (including nutrient loads) from the catchment area which is huge (97924 km²) as compared to the lagoon area (1584 km²) therefore the management plan for the catchment is of the high priority. However, being hyper-eutrophic, the lagoon water quality (including heavy cyanobacteria blooms) is mostly controlled by the ambient physical factors as wind climate and temperature (Pilkaityte & Razinkovas).

- In spite of quite extensive monitoring efforts (mainly from 1984) covering both water quality as well as hydro-biological, hydrological and climatic parameters quite important for hydraulic measurements of water levels in the Baltic Sea outside the Curonian lagoon are missing.

- Extensive dredging and increased authorization to allow for greater draft of vessels in the Klaipeda port altered the flushing rate for the lagoon.

Conclusions and recommendations

Monitoring

Monitoring of physical and biochemical properties is important for the scope of numerical modeling. The most important quantities to monitor are

- water level variations (almost continuous)

- river discharges (daily)

- temperature and salinity (continuous at open boundary, weekly or monthly in the inside), if possible also vertical structure

- water quality variables (monthly, but more frequent for river loading)

- meteorological parameters such as wind, radiation, air temperature, humidity, precipitation and evaporation, etc. (order of hour)

The quality of data should be checked continuously. Especially important are the regular calibration of the sensors (water level, T/S, wind) in order to provide reliable boundary conditions for the model. The sampling points should be representative for the variables measured.

Long term scenarios

In general 2-D models will be sufficient for analysis of consequences of pollution in the Vistula lagoon. Exceptions may concern the vicinity of the connecting strait. An approximate resolution of 1 km would be acceptable for these applications. This would be a compromise between the spatial resolution to be achieved and the temporal dimension that can be explored (which is in the order of years).

The problem of sediment transport and erosion and deposition can be described by suitable models. This is especially important for navigation (shipping channels) and coastal protection.

Problems might arise with exceptional events that cannot be modeled by this type of applications. In such cases it is possible to apply short term operational models and only in a second moment the results of the model could be aggregated for including them into the long term scenario.

The models could be used in the administration of long term pollution, fishery management and the definition of Total Daily Maximum Loadings (TDML).

Operational models

For the operational models available frameworks should be used. In the case of the Vistula lagoon this framework consists in coupling the local model with the available HIRLAM atmospheric model (Swedish Met and Hydrologic Institute, SMHI) and the HIROMB Baltic Sea model. These models provide the local model with the necessary boundary and initial conditions, both as hindcast and forecast (48 hours).

The local model should be integrated seamlessly into this framework in order to produce flood and storm warnings, forecast possible oil pollution at the coast and inside the lagoon, and help with rescue operations and lost dangerous items. In the case of simulations concerning short term analysis 3-D models would be more appropriate.

Coordination of activities

Data collection, to be useful for modeling work, should be uniform in time and space. This means that monitoring activities from different countries should be carried out in a way that the density and location of the network of data points are comparable and are taken during the same periods. Methodologies of sampling should also be uniformed across institutes and countries.

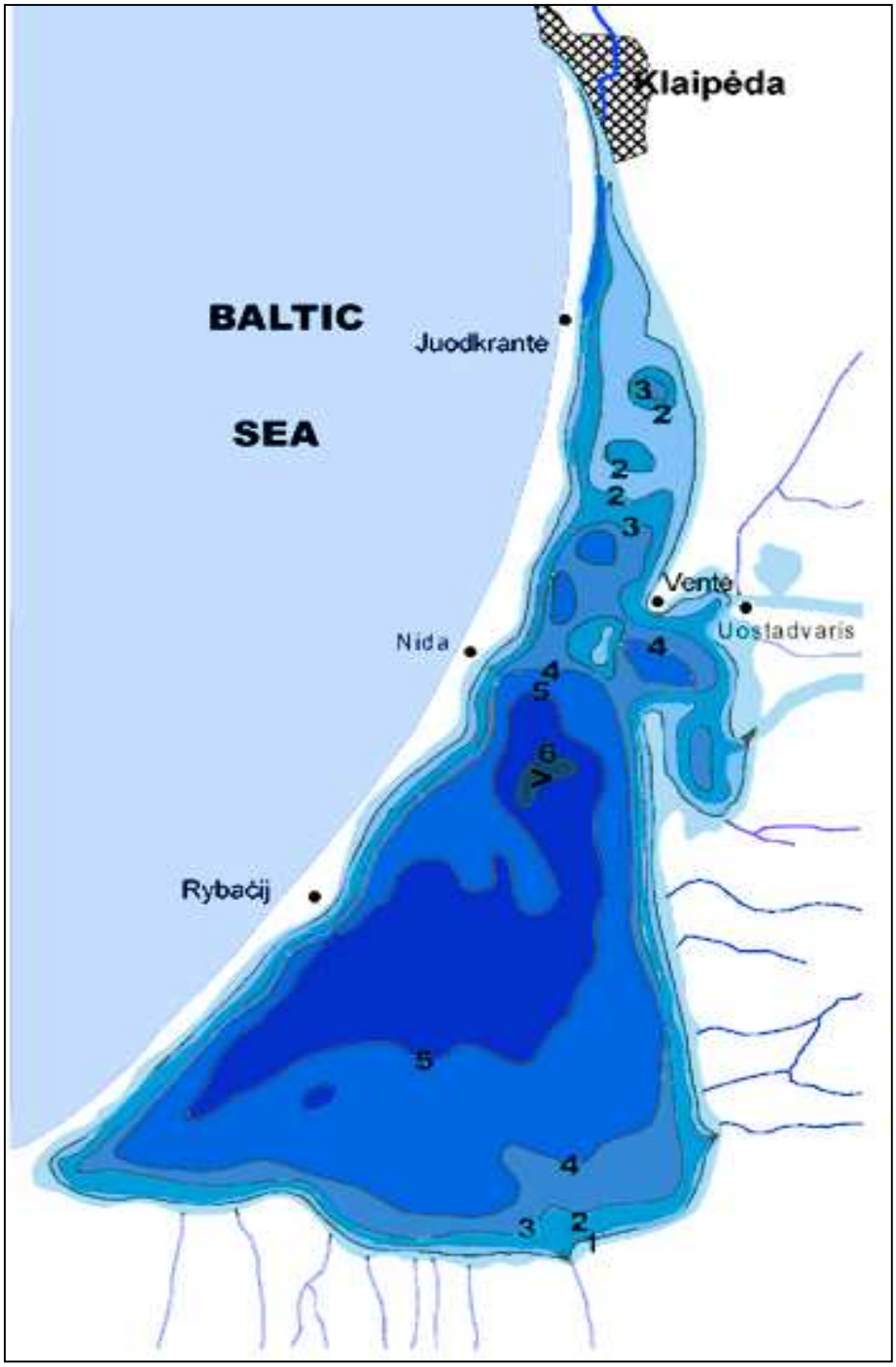

Fig. 1: The Curonian lagoon. Setting and bathymetry.

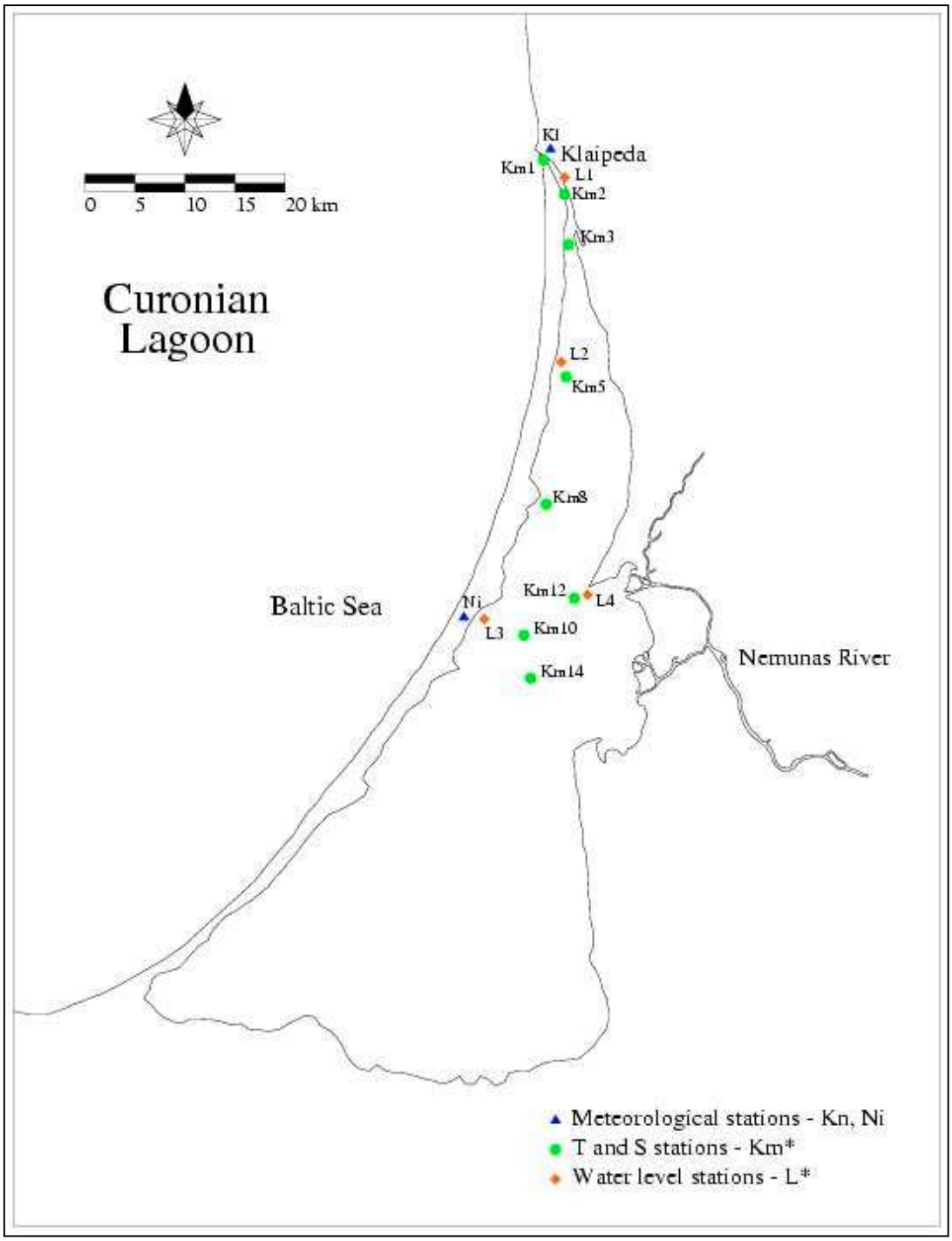

Fig. 2: Monitoring stations in the Curonian lagoon. Only the Lithuanian stations are shown.

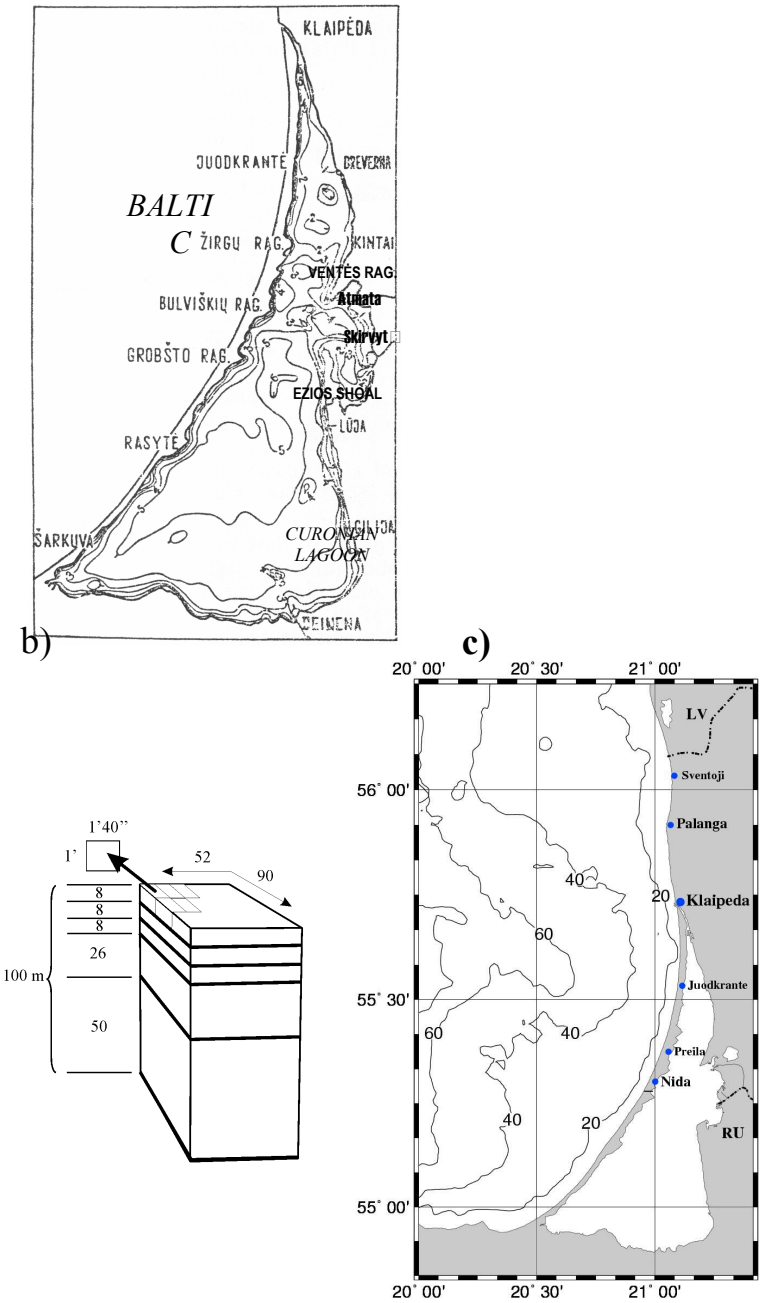

Fig. 3: The set up of the *BSHcmod* model. a) Parameters of discretization, b) topography of the model area, c) topography of the Curonian Lagoon.

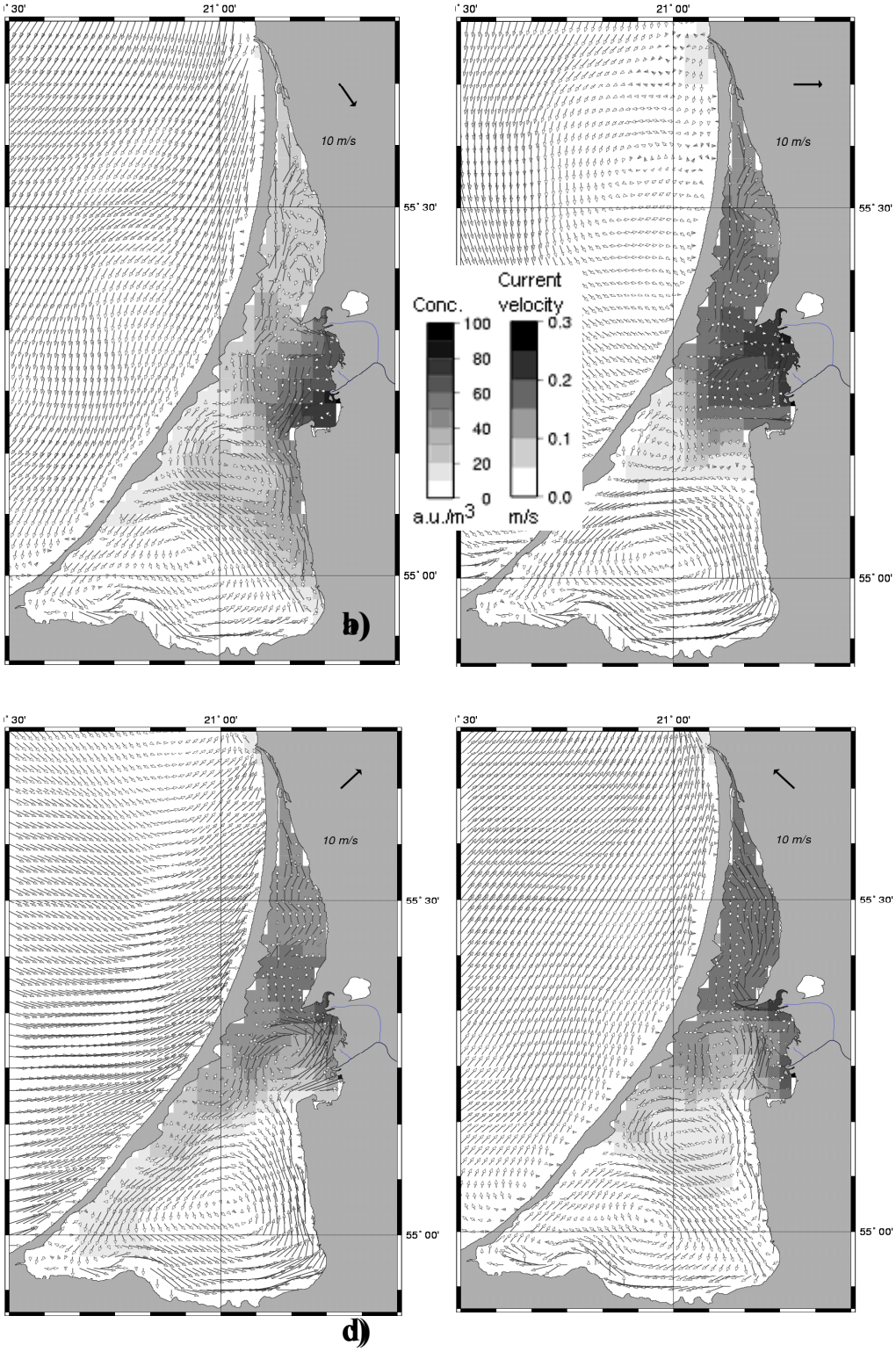

Fig. 4: Current and tracer distribution in the Curonian Lagoon in case of 10 m/s steady wind from the dominating directions: a) northwest, b) west, c) southwest, b) southeast. Conservative tracer, 100 a.u./m^3, penetrates the Curonian Lagoon with the Nemunas river water (the Atmata and the Skirvytė rivers). The tracer distributions after one-month simulation are presented. The currents in the Baltic Sea is reduced by factor 2.

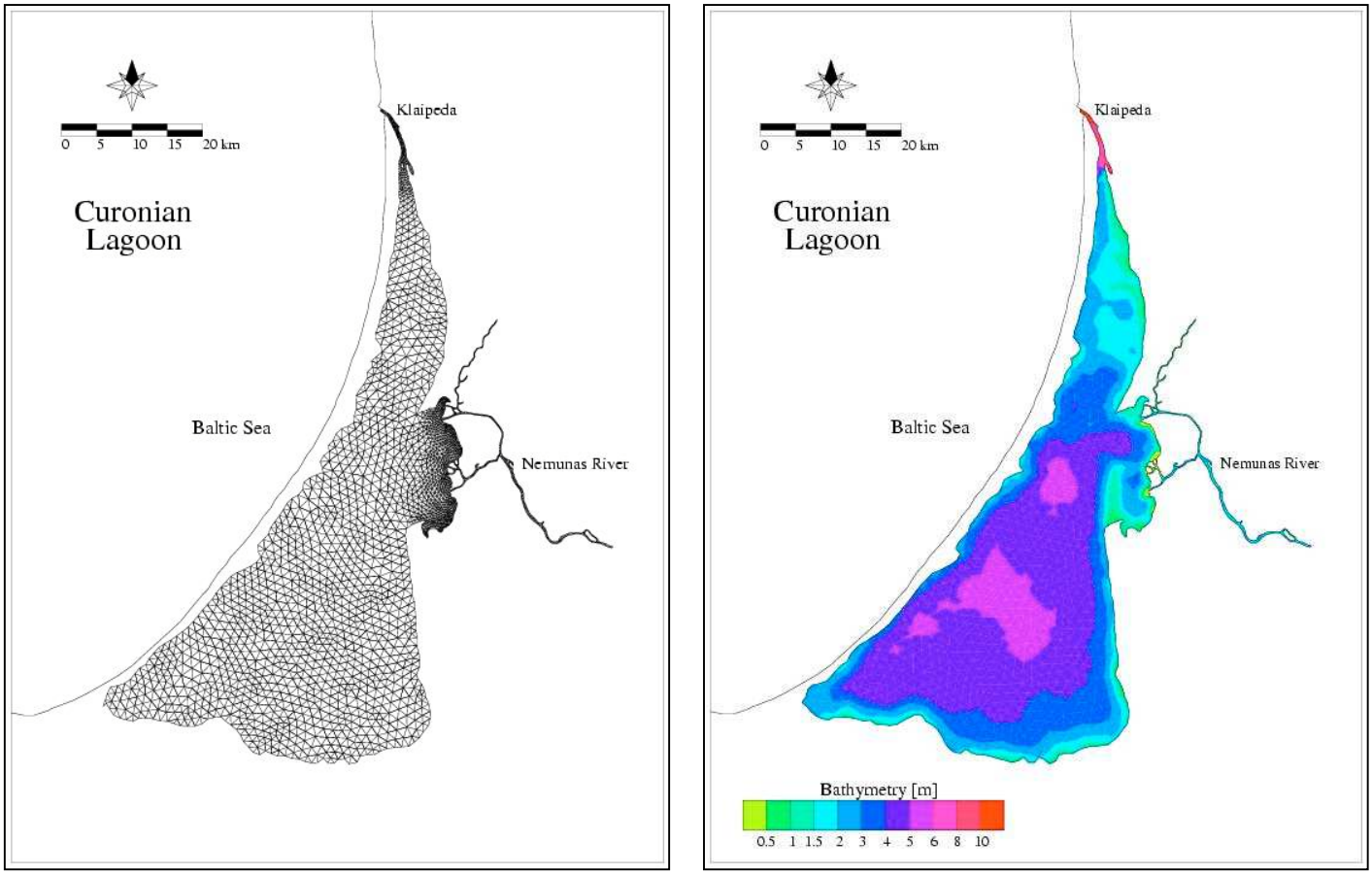

Fig. 5: Finite element grid and bathymetry represented by the numerical grid. The grid consists of 2486 nodes and 3859 elements.

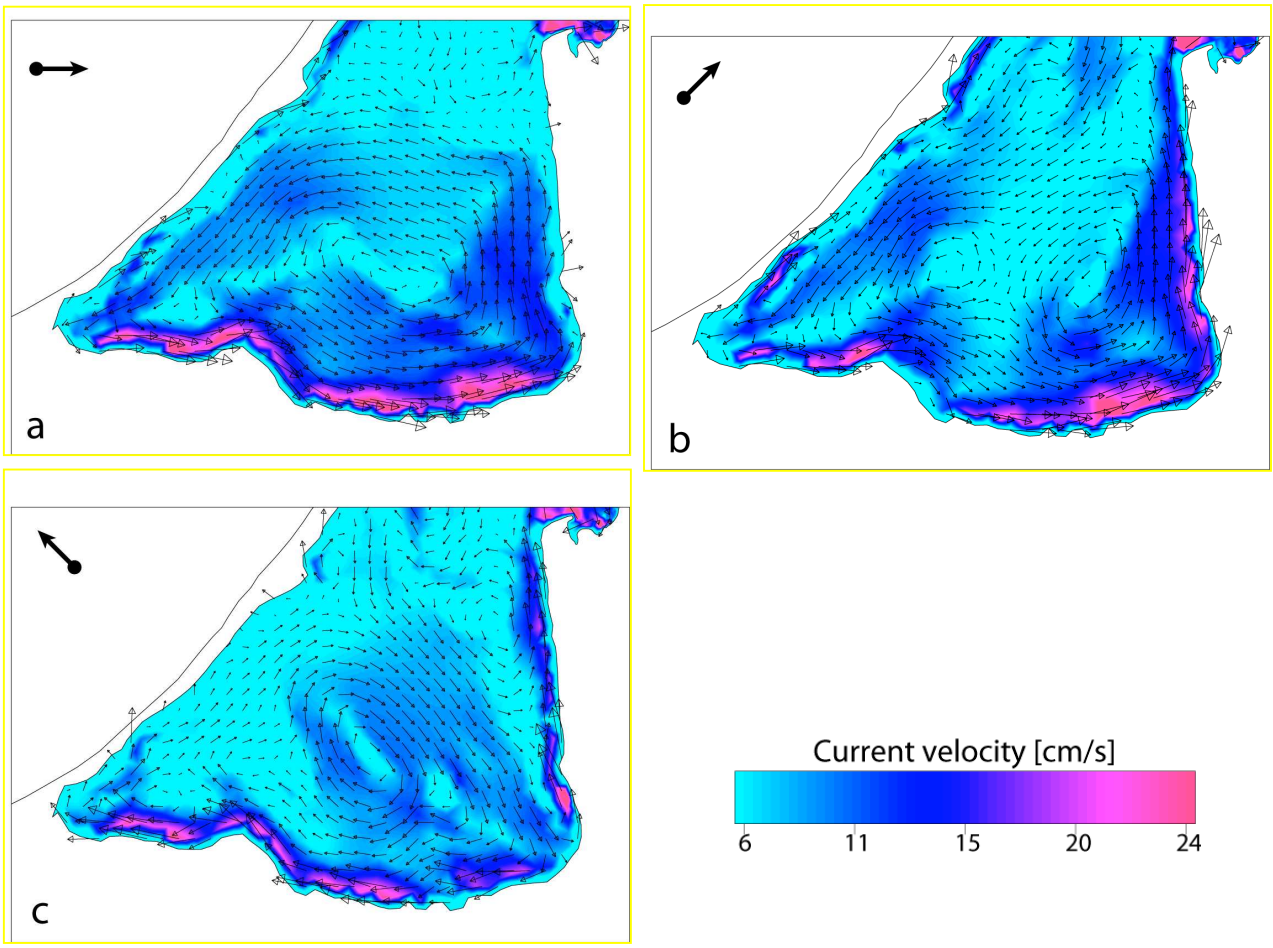

Fig 6.: Current circulation during various wind regimes. The highest currents can always be found close to the coast.

Report of the Decision Making Working Group for the Curonian Lagoon Workshop, Jodkrante, Lithuania, May 2004

Decision Making

The purpose of this report is to suggest a basic framework for making informed decisions and taking positive actions for sustained use and development of the Curonian Lagoon. Lithuania and Russia both have conventional decision making processes, although the countries differ on the level of authority provided and exercised at federal and regional levels of government. There are interjurisdictional / trans-boundary agreements for management of resource uses and issues. Among the most important the following are mentioned:

- Agreement between the government of Lithuania and the Russian Federation on the long-term cooperation between the regions of Lithuania and the Kaliningrad of 29 June, 1999;
- Agreement between the government of Lithuania and the Russian Federation on the cooperation in the field of environmental protection of 29 June, 1999;
- Agreement between the Lithuanian Environmental Protection Agency and Lithuanian Hydrometeorological Service under the Ministry of Environment and the Kaliningrad Centre for Hydrometeorology and Environmental monitoring on cooperation in the field of monitoring and data exchange on the trans-boundary water bodies of 21 October, 2003;
- Draft agreement between the government of Lithuania, government of Belorus and the government of Russian Federation on cooperation in use and protection of water resources of Nemunas river basin.

The agreements address in general terms management of fisheries and environmental protection. Further, collaboration currently exists on technical issues (e.g. fish, land protection). However, the key missing element for informed decision making and taking positive actions for sustained use and development is a Catchment / Watershed Area Organization. Such an organization is recommended and should include: (1) regularly scheduled meeting for technical work; (2) consistent membership / involvement of

individuals on technical work groups; (3) a formal working group at the Policy Level that meets regularly; (4) involvement of top leaders for each Country in establishing goals for sustained use and monitoring program implementation; and (5) stakeholder involvement.

Terms and Principles

Terms and Principles to be applied in implementing sustainable use and development practices:

1. Sustainable management is managing to meet present needs as well as providing for future generations to meet their own needs. Conceptually it requires the awareness and consideration of the ecological system. It, also, requires measurement of, and accountability of the values that an ecological unit, such as the Curonian Lagoon and its catchment /watershed area. It, further, requires measurements of and accountability for the values that the ecological unit provides to society.
2. Sustainable management is a conscious social decision that provides for the long term health of both the ecological and economic systems of the ecological unit. The finite capacity of the ecological unit's natural capital can not meet the growing demands of society without a plan for sustainable management.
3. The use of the best available information, knowledge, and tools needs to be infused throughout the decision making process. A monitoring program is a key factor in management for sustainable management.
4. The use of models as tools in the decision making process will enhance awareness of the interrelationships within the ecological unit, especially its input and output variables. This will further enhance accuracy of predictions for, and awareness of the consequences of decision on management actions.
5. Decision making should involve all interested parties including government (federal/national, regional, and local), non-government organizations (NGO's),

scientific institutions, business users groups and industry, agriculture, and tourism, and general public.

6. Management of decision making requires a formal cooperative institutional structure (CIS) that is empowered through appropriate policy and legal authority.
7. The CIS should have a written Charter or Agreement that commits the parties to work cooperatively to address the goal of sustainable use and development of the natural capital.
8. A conflict resolution process should be identified that provides ample and open consideration of differing view and interests.
9. Environmental education is essential in order to insure long-term sustainability of a participatory process. Education should be at two levels: (1) public awareness of the problems of the environment, especially the linkages between catchment area/watershed activities and consequences on the downstream water body and; (2) formal education of young people in order for them to understand the central role of the natural environment in their future welfare.

Recommendations

The following recommendations are respectfully provided as guidelines. They are based on successful work directed at sustained use and development of natural capital / resources in interjurisdictional / trans-boundary situations. It should be recognized that in different countries with different cultures the recommendations may need to modified to address unique interests of those involved.

1. Establish a Cooperative Institutional Structure (CIS), empowered through appropriate policy, legal, and financial instruments. An example is provided in Appendix 1.
2. Establish a Charter, a formal Letter of Agreement that commits cooperation between

National and Regional governments. The Charter / Agreement will serve as a framework for collaboration on the development and implementation of agreed upon goals for sustained use and development of the Curonian Lagoon and its catchment / watershed area. The signatories should be at the highest levels of the respective governments, and this group will serve as an Executive Committee. (Existing Agreements need to be inventional and referenced as basic tools for guiding Management decisions.)

3. Establish a Policy Committee and identify specific staff to service and manage the CIS. The Policy Committee will identify policy / legal needs and seek consistency in management of trans-boundary issue. The staff needs to include experts in lagoon management and conflict resolution. The Policy Committee also should serve a functional role in directing representatives from the technical working groups (noted below) priority work issues.
4. Establish Technical Working Groups. The following working groups are recommended: Water Quality, Nutrients, Toxics, Hydrologic, Hydrobiological, Coastal Monitoring, Fisheries, Exotic/Invasive Species, Dredging, Migratory Birds. Working Groups should be established to address local needs and national interests. These groups will establish plans to address agreed upon (at Executive and Policy Committee levels) goals and objectives. These groups also will recommend goals and objectives to Executive and Policy Committee for adoption.
5. Establish Advisory Committees for the general public (citizens), scientific and technical interests, local governments, and non government organizations (NGO's). Other Advisory committees also may be appropriate to meet local interests and needs.
6. Invite stakeholder involvement from all businesses that have an interest in Curonian Lagoon and its catchment / watershed area. This should include representatives from

industry, agriculture, fisherman, tourist industry (developers and managers), and others.

7. Hold Round Table meetings at each level of the CIS on a regular basis. For example:

   - Executive Committee – Annual
   - Policy Committee – Bi-annaul
   - Working Groups – Quarterly

8. Facilitate decision making process by modern and joint tools for trans-boundary management, like united data base and modeling tools for impact assessment. Establish procedures of data base replenishment and access to data base resources as well as exchange of information for environmental impact assessment and operational needs.

9. Establish a formal dispute resolution process. Differences of opinion need to be elevated to higher authority within CIS to ensure that sectorial competing interests for national capital are fully considered.

10. Establish an environmental education program directed at (1) public awareness of the problems of the environment, especially the linkages between catchment / watershed area activities and consequences on the downstream water body(s) and; (2) formal education of young people (education curriculum for primary and secondary levels) in order for them to understand the central role of the natural environment in their life and life of future generations.

11. Establish a planning process. The planning process can be simple. It can be described as the following seven step process on components listed below:

    1. Set the goals for sustainable use and development of the Curonian Lagoon and its catchment area/watershed.
    2. Define problem(s) – describe the problems/conditions that affect the Curonian Lagoon ecological and social-economic structures.

3. Define the system – Curonian Lagoon's ecological and socio-economic structural components.
4. Develop and use an effective decision support system, a CIS.
5. Develop and integrate this plan into the infrastructure by function (committees and workgroups of the CIS).
6. Formulate Action Plans to address identified needs for information, policy, and legal framework.
7. Evaluate progress on a regular basis (at least annually by the Executive Committee and Policy Committee).

Conclusion

Lithuania and Russia should take great pride in the level of collaboration that is occurring. The recommendations provided are suggested as guidelines to improve their working relationship. Specifically, to improve the effectiveness and efficiency of decision making on interjurisdictional / trans-boundary issues for the purpose of sustained use and development f the Curonian Lagoon.

The recommendations provided are suggested only to improve the effectiveness and efficiency of decision making on trans-boundary issues.

Attached is a list of participants in the Decision Making Working Group at the Curonian Lagoon Workshop, Jodkrante, Lithuania, May 2004.