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The Northumberland Strait Crossing Project
Projet de traversée du Détroit de Northumberland
Die Ueberguerung der Meerenge von Nordthumberland

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SUMMARY

The construction of a fixed link in the Northumberland Strait between the Canadian provinces of New Brunswick and Prince Edward Island is not a novel idea, i. e. it has been the subject of a century old debate. The concept of a link, whether a tunnel, causeway, or bridge, experiences periodic revivals. The debate progressively became part of the Prince Edward Island tradition, but the public now expects that project development should not only consider the effects of the environment on a project but also the impact of that project on the environment in its broadest sense.

Projet de traversée du Détroit de Northumberland

Résumé
La construction d'une liaison permanente sur le Détroit de Northumberland entre les provinces canadiennes du Nouveau-Brunswick et de l'Ile du Prince Edouard n'est pas une idée nouvelle. Elle fait l'objet d'un débat centenaire. La conception d'une liaison - qu'il s'agisse d'un tunnel, d'une route ou d'un pont - est soumise à des considérations périodiques appartenant à la tradition de l'Ile du Prince Edouard. Mais la population exige maintenant que le projet ne considère pas uniquement l'influence de l'environnement sur le projet mais aussi l'impact du projet sur l'environnement dans son sens le plus large.

Die Ueberquerung der Meerenge von Nordthumberland

Zusammenfassung
Der Bau einer festen Verbindung zwischen den kanadischen Provinzen New Brunswik und Prince Edward Island über die Meerenge von Nordthumberland ist keine neue Idee; schon seit einem Jahrhundert wird darüber diskutiert. Ob ein Tunnel, ein Damm oder eine Brücke gebaut werden soll, steht immer wieder zur Debatte. Diese Debatte gehört mittlerweile zur Tradition von Prince Edward Island, aber die Oeffentlichkeit erwartet heute, dass bei der Planung dieses Projektes nicht mehr nur die Auswirkungen der Umwelt auf das Projekt, sondern auch die Auswirkungen des Projektes auf die Umwelt berücksichtigt werden.

1. ONE CENTURY OF DEBATE

The nature of the public debate has evolved substantially over the past century depending largely upon the preoccupations of the time, such as, nation building, economic growth, industrial development or, most recently, the concerns over the environment. In all cases, the discussion was centred around the basic need that people have to keep control over their own lives and their collective destiny.

The idea of providing continuous communication between the Island and the Mainland was a condition enshrined in the Terms of Confederation, signed between the Federal Government and the Province of Prince Edward Island when it joined Canada in 1873. At that time ice breaking ferries were not reliable for the transportation of people and goods across the Strait in all seasons.

In 1885, John Howlan, a Senator from the Island, first conceived the notion of a link, and his persistent lobby for a tunnel eventually led to the first feasibility studies. Evidently in those days, public participation consisted of the enrolment of the opinions behind the idea of a link. Like the construction of the intercontinental railway system, the fixed link was one of several major projects which were essential elements in the building of a new and prosperous country. If you were of the opinion that the union with Canada was a positive step in the history of your island, you certainly became a supporter of the link. The technology which came out of the first world war led to the construction of efficient ice breaking ferry boats, and the idea of a link was abandoned as the first all season ferry service started in 1917.

In the 60s, the pursuit of affluence was on the mind of North Americans. The notion of a fixed link was revived as an instrument of economic prosperity. In 1967, a serious attempt to build a causeway-bridge was undertaken and approach roads were built to connect with the Prince Edward Island and New Brunswick highway networks. The participation of the public in this endeavour was minimal as no formal consultation process was in place. The desire for prosperity was the main motivator and the notion of environmental protection was in its infancy. In 1968, as the project was ready to be awarded, the Island opted for a 15-year development plan and an improved ferry system.

Since 1968, traffic had been increasing considerably, ferry costs were rising, and there were expressions of discontentment with the level and quality of the ferry service especially during the summer months.

In 1985 and 1986, some private sector Canadian companies submitted unsolicited proposals for the construction of a fixed link, with the conditions that the Federal Government would make available the subsidies which are presently granted to the ferry service and that the developers could charge tolls. This presented a window of opportunity which the government could not afford to ignore. At a time when considerable strain is placed upon the public purse, this venture fits into the policy decision of the present government to rely on the private sector for major development initiatives and leadership of the economy. In 1987, the government authorized the necessary studies to determine the feasibility of such a project and to gauge private sector interest in developing the link.

2. THE ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS

In Canada the Federal Government has established formal project development guidelines which have the force of law. Essentially, they reflect the high level of awareness of our citizens over environmental matters and constitute a democratic response of government to their exigence for public consultation. All federal development projects are therefore subject to the Environmental Assessment Review Process (EARP), from the early planning stages through to the construction phase. These legislated guidelines include a full Initial Environmental Evaluation and require that the initiating departments, in this case Public Works, ensure that the public has access to project information and the opportunity to respond to the proposal.

Public Works Canada's original feasibility studies, coupled with a comprehensive program of public participation, constituted the main body of the mandatory Initial Environmental Evaluation.

Early consultation revealed that public support for the project would not be readily obtained. The legacy of controversy which had marked the project history was enhanced by the current issues of protection of the environment and preservation of the Island way of life. The process guaranteed that the project could not possibly proceed unless the public was satisfied that the resulting level of socio-economic and environmental impact was acceptable. This principle directed the requirement for public participation in its development. As a responsible proponent and because of the necessity to abide by the EARP process, we knew that the public had to be more deeply involved in the planning.

Public Works developed a strategy which provided full access to all project information including the compendium of studies, impact identification and analyses as well as decision timeframes. The strategy also outlined and directed the inclusion of public comment into the project development which dealt with the environmental and socio-economic impacts of a link. The idea being that, even as responsible initiator, it is not good enough to conclude that the level of impact is acceptable, you must conform to the public's view as to what constitutes acceptable impact.

The cornerstone of public involvement in the project is a two-way communication thrust. On one hand, the quality of the public input in the project depended largely upon their understanding of the project alternatives and their consequences. On the other hand, mechanisms had to be established to encourage public discussion and to gather the public input. It was clearly understood that public information was the key needed to a successful public participation process.

One of the main stays of our public information campaign has been the establishment of a street level office in Charlottetown. It works as a resource centre making our studies available to everyone interested and encouraging drop-in visitors to discuss the issues related to the project. With time, this office became a focal point for the media to access information and project staff. Another successful endeavour has been the publication of STRAIT FACTS, a public newsletter with broad distribution. This newsletter is still published on an ad hoc basis and continues to report on the issues and events related to the project. Its primary purpose is to provide a forum for public comment.

3. PUBLIC CONSULTATION AND IDENTIFICATION OF PROJECT IMPACTS

In order to determine the public concerns and identify the specific groups which were affected, Public Works commissioned a social impact study. Some of these interest groups were visible from the outset, others not so.

It should be noted that identification of impacts, the treatment of these impacts, the project feasibility studies and public information and consultation were part of an ongoing process. These activities, including constant dialogue with the public, took place in parallel and would eventually lead to the determination of project feasibility and project parameters.

To a large extent, ongoing public consultation helped to confirm and refine the impacts which, as a responsible initiator, Public Works had identified. They covered the broad spectrum of socio-economic and environmental consequences of building a link.

The fishermen, through their associations, expressed concerns over the disruption of their activities and of the fishery in general, resulting from the construction of a project of this size in the prolific waters of the Strait. They expressed concerns that bridge piers would create ice jams, affect the ecology of the Strait and delay the start of the fishing season. Fishermen supported a tunnel because it would not impact on the marine environment.

Since the link was to replace the existing ferry service, the ferry workers expressed serious concerns over the abandonment of the ferry service and the loss of their jobs. Also, dwindling economic activity in the two ferry towns of Tormentine and Borden would affect the community at large.

In contrast, other groups such as the tourism and trucking industries, the construction and engineering associations and the potato farmers would benefit from a link and expressed interest in seeing the idea explored further.

Public involvement extended beyond the local interest groups. At the onset a broadly based project planning committee, chaired by Public Works, was formed to ensure consultation with all interested Government parties. The Committee included representation from the Governments of the three Maritime provinces and a dozen federal departments. Their input in identifying impacts and proposing solutions was extremely valuable to the process.

As part of the feasibility studies, we also had to determine if there was enough interest and capacity in the private sector to undertake a project of this significance. Twelve consortia responded to our May 1987 call for expression of interest. The screening resulted in seven developers being shortlisted.

4. PUBLIC CONSULTATION AND PROJECT FEASIBILITY

The compendium of feasibility studies and confidence of the support expressed in the plebiscite led the Federal Government to draw the following conclusions:

1. Either a vehicular tunnel or a bridge would be cost effective and provide continuous transportation between the Island and the Mainland.

2. The project could be undertaken with an acceptable level of risk and socio-economic and environmental impacts could be avoided altogether, reduced or generally mitigated.

3. It was also concluded that the private sector had the capacity to undertake a project of this significance under the specific public/private sector approach chosen.

This approach is often refered to as the **F-BOOT system**. The developer and his team will **Finance, Build, Own, Operate and Transfer** the structure back to the Government, in conformance with the terms of an agreement.

5. PLEBISCITE ON PRINCE EDWARD ISLAND

As the project was gaining momentum, the provincial government of Prince Edward Island announced a plebiscite on the issue of a link. In preparation for the plebiscite, the provincial government organized a series of activities to enhance the level of discussion over the project and its impacts. Public Works was invited to participate in panel debates. This provided additional opportunities for extensive public participation.

Two major lobby or interest groups attempted, with a fair amount of success, to crystallize the public opinion. On one side, the "Friends of the Island" showed their strong opposition to the project while the "Islanders for a Better Tomorrow expressed their conviction that the project should proceed for economic reasons.

On January 1988, in answer to the plebiscite question: "Do you favour the construction of a fixed crossing between Prince Edward Island and New Brunswick?", 59% of the Islanders demonstrated their support for the project and replied "Yes".

6. THE PROPOSAL CALL

Subsequently, conditions for the project were established which took into consideration the socio-economic and environmental impacts which we had identified and which had been confirmed and refined through our public consultation process.

1. The majority of the risk to be assessed by the developer and reside in the private sector.

2. The project must be environmentally sound.

3. The project must maximize regional and industrial benefits to Atlantic Canada.

4. There must be cost and time certainty.

5. The cost of the project to government must be no more than the avoidable cost of the ferry service it is meant to replace (approximately $ 40.5 Million 1990).

A call for proposals was issued in March 1988, asking the consortia to address all these conditions in their submissions.

All the project parameters and the terms of the proposal call were widely publicized at the time. We wanted to ensure that the public clearly understood that the socio-economic and environmental impacts of the project which had been identified through our studies were fully integrated into the project requirements from the onset. These impacts would be fully addressed by the developer and the crown, breaking away from the traditional notion that such effects should be considered as impediments and dealt with as an afterthought once the project is underway.

As a result of the Proposal Call, six developers filed seven proposals: six bridges and one tunnel.

Only proposals which fully complied with all the terms of the proposal call would be acceptable and eventually proceed to the pricing stage.

In September 1988, as a result of the proposal evaluation process, three bridge proposals were retained as fully addressing the project requirements and one tunnel and three other bridges were rejected because they did not meet the criteria.

The successful developers were:

- Strait Crossing Incorporated,
- PEI Bridge Limited, and
- Borden Bridge Company Ltd.

7. FORMAL PROJECT REVIEW BY PANEL

From the initial stages of the project, our approach involved serious consideration of the concerns expressed by the public as well as the development of mitigative measures to address the project impacts. By the time the proposals had been evaluated, we had determined that the environmental and socio-economic consequences of the project had been satisfactorily addressed and that soon we would be able to proceed to the next step of development, which is the financial and pricing stage.

Nevertheless, the lengthy process of public information and consultation revealed that there was still a fair degree of public concern among the population that our efforts had not been put to rest. Because of its perceived position as judge and jury, Public Works Canada could not successfully dispel the popular notions over the impacts of a fixed link. The government therefore decided to elevate the process to the highest level of public assessment which is the EARP Panel process.

In January 1989, the Minister of Public Works asked the Minister of the Environment for a formal public review of the project by panel. This mechanism is part of the Environmental Assessment Review Process and is always available if required. The Federal Environmental Assessment Review Office, under the authority of the Minister of the Environment, is an organism which is responsible for the coordination of panel reviews under the EARP.

Five prominent citizens of Prince Edward Island, New Brunswick and Nova Scotia were invited to adjudicate whether the concept of a bridge, as the only option which has satisfied all the requirements, was acceptable from the environmental and socio-economic perspective. In addition, they were to review the reasons for the rejection of other types of crossings. From then on, the process was no longer in the hands of Public Works.

As part of the Panel process, Public Works developed the Bridge Concept Assessment, which could be described as a statement of the impacts of a generic bridge in the Strait. The reason for the generic bridge concept is that the specific proposals were proprietary and their individual features could not be made public without jeopardizing the competitive process.

Following the publication of the Bridge Concept Assessment and its review, the Panel conducted a series of public scoping meetings in various communities on each side of the Strait. Over a dozen public meetings were organized by the EARP Panel to help them identify the specific concerns and focus on the issues. Upon the completion of the scoping sessions, the Panel requested some additional information from Public Works, which led to further research and analysis. This additional information was published as a Supplement to the Bridge Concept Assessment and allowed the Panel to decide that there was sufficient background information available that meaningful formal public hearings could be held.

In March of 1990, 21 formal sessions were held in the three Atlantic provinces concerned. This gave an opportunity to some 150 individuals and representatives of interest groups to express their opinions on the fixed link. Some sessions dealt with general and community concerns while others focused on more specific areas of impact, such as, the interaction between a bridge and the ice regime in the Strait, the effects on the socio-economic fabric, the influence of a link on the traditional Island way of life, etc. As the initiator of the project, Public Works' role consisted mainly of presenting our findings and answering questions related to our conclusions. The media coverage of the formal hearings enhanced the discussion and raised the level of awareness over the issues.

In August 1990, the FEARO Panel presented their report to the Ministers of Environment and Public Works. This report was published immediately. In essence, the FEARO Panel report constitutes the culmination of the public consultation process and represents the final compendium of recommendations to the government. In their report, the Panel concluded that the majority of the impacts which we had identified were valid and properly addressed. Nevertheless, on one specific account, which deals with the effect of a bridge on the ice regime, the Panel determined that such a structure could lead to unacceptable effects "on the marine biota, the fishery and coastal agricultural micro-climate". In the process, they also established the maximum level of impact which may be caused by an acceptable bridge and suggested how to deal with the unacceptable risks associated with a bridge concept. In their opinion, "risks associated with a maximum ice-out delay of two days over a period of 100 years would be acceptable".

After a thorough review of the Panel report, the government accepted the assessment of the Panel and decided that any bridge selected must not increase the ice season by any more than two days, any year, over a hundred years. This led to a major review of the ice issue and may impact on the engineering of the project. Independent ice experts have been

hired to review the ice model and make the changes required to improve its predictive capability, including those changes suggested by the Panel. They will also advise the government whether the three bridge proposals which are in the running meet the ice criterion established by the Panel. In order to preserve the integrity of the process, the government has requested that the ice experts publicly demonstrate how the revised ice model reacts against a variety of bridge features. To that effect, information sessions will be held on the Island which will demonstrate the reliability of the model as a dependable measuring tool of the interaction of the ice against bridge piers.

8. CONCLUSION

Public involvement and open communications have been integral to the entire planning process, and if the project proceeds, public participation will continue throughout the life of the project. Should the government decide to proceed with this project and select a specific bridge proposal which meets the environmental and financial criteria, the agreement with the developer makes him responsible for publicizing the specific elements of that proposal along with his environmental management plan. This plan will be scrutinized by the public who will have the opportunity to influence its contents.

The public consultation process, as applied to the Northumberland Strait Crossing Project, is a very democratic process which provides the tax payers with an opportunity to receive all the necessary information about the project and to knowledgeably provide input into its development. Some significant conclusions can be drawn from our experience with public consultation. It provides an opportunity for constructive input by the public at large. Its assists the sponsor in establishing the level of acceptable impact of a project, beyond the analysis of experts. This process also contributes to improving the quality of work done by these experts who may find that they must corroborate their conclusions by enhancing the quality of their documentation and producing further evidence to support their findings. Following close scrutiny by both experts and the public at large, it seems that a project of this significance could proceed with further assurance of conservatism in dealing with its impacts. Lastly, it is clear that the involvement of the public at the early stage of project planning and development gives the private industry and their financial backers a high degree of confidence that, once the decision is made to proceed to the implementation stage, the majority of the possible stumbling blocks have been resolved.

Public Support, Keep it Awake
Avoir en permanence le soutien du public
Oeffentliche Unterstützung - sollte man pflegen

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SUMMARY
Based on practical experience with planning of projects and formulating of policies, an approach in planning and management of civil engineering projects is developed. The approach consists of a phase of public recognition of the problem, a phase of formulating alternative solutions, a phase of choosing a solution and realising it and a phase of management. The main object of the approach was to provide the opportunity in every phase for interaction with public opinion and to gain and hold public support. The main point of view in this paper is the relation with public opinion and public support.

Avoir en permanence le soutien du public

Résumé
Basé sur une expérience pratique, une approche de la conception et de la gestion de projets de génie civil est présentée. Elle consiste en une phase d'acceptation du problème par le public, d'une phase de formulation de solutions alternatives, d'une phase de sélection d'une solution, de sa réalisation et de son exploitation. Cette approche a pour objectif de permettre une interaction avec le public dans chaque phase de la réalisation, afin de gagner et garder son soutien. Le point principal de cet article est en relation avec l'opinion publique et le soutien public.

Oeffentliche Unterstützung - sollte man pflegen

Zusammenfassung
Basierend auf praktischer Erfahrung wurde ein Verfahren in Planung und Management von Bauingenieurprojekten entwickelt. Das Verfahren besteht in einer Phase öffentlichen Bekanntmachens des Problems, einer Phase der Formulierung alternativer Lösungen, einer Phase der Lösungswahl und ihrer Verwirklichung und einer Phase des Managements. Das hauptsächliche Ziel dieses Verfahrens war, in jeder Phase die Gelegenheit zum Austausch mit der öffentlichen Meinung zu ergreifen und die öffentliche Unterstützung zu gewinnen und zu halten. Der Hauptgesichtspunkt in diesem Artikel ist die Beziehung zwischen öffentlicher Meinung und öffentlicher Unterstützung.

1. INTRODUCTION.

Civil engineering projects usually serve public interest: Watermanagement, coastal defence, reclamation of land from the sea, etc. However, many civil engineers sometimes have difficulties to get the most necessary project started. In several cases public resistance is growing against the project during realization which often takes years or decades. Sometimes it results in essential modifications of the original design of the project. In other cases it even means the end of the project. Sometimes the public interest as translated in the project, fades away or one or more objectives of the project disappear. In a number of cases ecological effects cause the public resistance. The papers of only one symposium [1] showed the next examples:

* Deltaproject (S-W Netherlands) [1a]. Main interest (1958) was flood control by closing estuaries from the sea. Another objective was to replace salt water with fresh water for agriculture. Public opinion said in 1973: Salt water nature and shellfish culture are more important then fresh water. That resulted in a salt lake Grevelingen [1b] instead of a fresh water lake and in a stormsurgebarrier in the Eastern Scheldt leaving room for tidal water movement instead of a dam [1c].
  Recently public opinion called for a stormsurgebarrier in Rotterdam Waterway instead of raised dikes in towns and villages.
* Zuiderzeeproject (Central Netherlands) [1d]. Main interests (1932) were flood protection and the reclamation of land out of water for food production in 5 polders. Public opinion (1980) said: A fresh water lake for nature, fishing and watersports is more important then land for food production. That resulted in the cancelling of the 5th polder. This means the end of 7 centuries of landreclamation: 20% of the Netherlands consists of reclaimed land.[2]. Today the lake is a wetland.
* Waddenzeeproject (N Netherlands) [1e]. Main interest was land reclamation from the Wadden Sea. This project started stealthy in the 1930s. Public opinion (1970) said: The estuarine environment is more important then land reclamation. That resulted in cancelling the project. Today the Wadden Sea is an international wetland area.
* Nakanoumi project (Japan) [1f]. Main interest (1963) was the reclamation of land for rice production. Public opinion (1975) said: Nature and fisheries are more important then rice production. That resulted in cancelling the construction of a dam although sluices and locks were finished.

Another example is the Siberian project to reverse the direction of the flow of a river. This project was cancelled by Gorbatsjov after public resistance all over the world. Recently public resistance is growing against the stormsurgebarrier which is under construction near Leningrad. This resistance is caused by serious waterpollution which however is not related to the barrier. So this might be an example of irrational resistance.

After the realization of a project the budget for the maintenance of public work is often too low. Even in the Netherlands - with their history as a subsiding country and a rising sealevel over centuries - the budgets for maintenance of flood protection works were often insufficient. By analyzing this phenomenon a cycle could be recognised [3]:

* an inundation with its traumatic consequences in losses of life and goods brought a national consensus: "this never again, dikes have to be raised".
* after 2 or 3 generations the public awareness of the danger to be flooded decreased and consequently the degree of protection decreased too.
* the 3rd or 4th generation could look forward to a next inundation.

In the field of basin management similar experiences are available. The Eastern Scheldt stormsurgebarrier was realised instead of a dam to preserve the estuarine system (costs doubled to 4 billions of guilders). Then (1978) the objective of basin management in the Eastern Scheldt basin was chosen: To

preserve the natural system - even to improve it where possible - and to continue shellfish culture. Today it is difficult to protect nature from a too high increase of fishing a certain species of shellfish (Cardium Edule). These species are especially important because they form the greatest biomass in the basin and are food for many birds.

From the recent experience with the formulation of the new erosion control policy of the Dutch coast, the conclusion can be drawn that public opinion and public support often are the keys to gain and to keep attention for essential issues. Of course: In democratic societies politicians decide on priorities. And politicians do their job in interaction with the public opinion.

That leads to the central problem definition of this paper. "What are the possibilities for the government and its civil servants to interact with public opinion and to hold public support over many years or decennia during the planning and the realization of a project and afterwards during the maintenance?"

Fig. 1. Mobilizing the public opinion: A key factor.

First of all the answer will be given based on practical experience. This experience is gained working on projects and observing the interaction between project, politics and public opinion. The experience is supplemented with some information from literature. The practical base forms the approach in the next sections and is in the first place rooted in the Dutch society. On the other hand foreign literature indicated that the approach might be useful in other well developed societies where people think independently.

The approach will be worked out for the planning, the realization and the maintenance of civil engineering projects. The same approach is suitable for the formulation, the acceptance and the realization of more abstract policies.

2. PUBLIC OPINION, PUBLIC SUPPORT AND POLITICS.

2.1 Public opinion and politics.

Public opinion rules in a democracy [4]. This could be a direct democracy where all citizens are directly involved in decision making. However in practice a small number of chosen politicians represent voters in parliament and government. They interact with public opinion.
Politicians have their own rationality. Often one or more of the next three criteria can be recognised [5]:

a. Public interest.
b. Rules and routines of the authority.
c. Striving to stay in power, so to be elected again.

Politicians mix these criteria to their own combination which changes from time to time. Of course the striving to stay in power is important. Otherwise a politician can not continue to work for public interest. It makes polticians sometimes seem to have their agenda dictated by press and public opinion. Some politicians rise to the level of a statesman. The latter are mostly concerned with public interest on the long term and are able to get public support for

their ideas. This way their agenda is not dictated, but they appoint the political agenda. Also a statesman can only bring his ideas effective to the public if he knows his public. So he has to be in contact with the public and he has to listen what is going on [6]. Anyhow, for every politician public opinion is important. So it is for civil engineers in civil service.

A civil engineer in civil service - both as he is working as a policy formulator and as he is working more closely to technics - has from time to time to support his political superiors to inform the public about good or bad news. The approach of politicians and engineers is often decisive for the public opinion about their project. Some remarks are:

* Politicians dislike to bring bad news. Examples are: Negative ecological effects of a project or exceeding the original budget. If possible such bad news has to be explained of external influences such as an exceeding inflation in the marketsegment.
* Politicians prefer to avoid complicated messages that are difficult or hard to explain. Keep it simple.
* Policies without visible success are impopular. Such policies are sufficient management or maintenance which are never spectacular.
* Projects with short term success have an advantage on projects with a long term success. The success of the latter might be harvested by a successor. That might be the reason why decisions on public investments have a disadvantage on projects in a consumptive atmosphere.

Looking at the latter two items. A decision with long term effect can enhance the image as a statesman from the responsible politician. Such a decision presented just before elections might be attractive from a political point of view. Timing is important for a public discussion. When a discussion starts one or half a year before elections, political parties might use it as a topic in their program. After the elections it can be written in an agreement between ruling parties. It is a method to quick popular decisions.

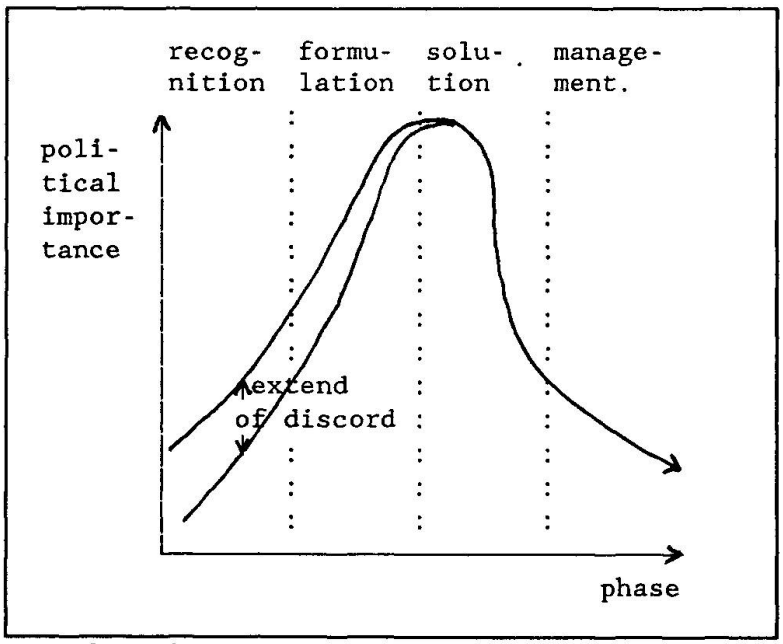

Fig. 2. Policy lifecycle.

The political importance of questions depends on the phase of a project. The succesfull former Dutch minister of environment, Winsemius, recognised the policy lifecycle [7] as shown in figure 2. To get recognised a problem is sometimes very difficult. Often bad news or an incident is necessary. The Sandoz disaster (1987) - seriously polluting the river Rhine - is an example of such an incident. It pushed the international Rhine action plan forward. A logic continuation was the action plan for the North Sea. It was more difficult to reach an agreement on the latter. The sea seems to stay far from our backyard. Fortunately Greenpeace mobilizes public opinion. If that was not he case, only dying seals like in 1988 could do this. The figure also illustrates that the phase of management (maintenance) is the least interesting in politics.

2.2. Influencing the public opinion.

The media can help to consolidate an existing public opinion. To change an attitude in public opinion is more difficult, especially an existing issue. Considering the long realization period and required lifetime of civil engineering projects, attitudes have to be influenced for longer periods. This leads to fig. 3 [9]. People strive to the equilibrium between the 4 pillars of attitude. Values (ideas and feelings) weigh the heaviest. For continuing influence on an attitude, it is necessary to appeal on the values of people. The Brundtland report may be an example summoning for "sustainable development of society": This generation inherited the earth with specific chances to survive and ought to leave the earth in a condition giving their children at least the same chances to survive. This appeals to a basic value of people, their parenthood. Such appeals are issues for statesmen.

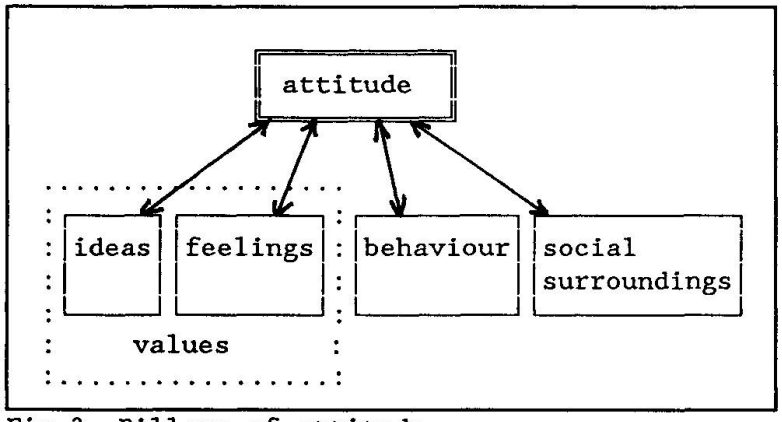

Fig.3. Pillars of attitude.

Today the Dutch politics is involved with long term environmental policies. This is not only caused by the Brundtland report, but might also be caused by other facts. Around 1970 young academic people at universities were educated in environmental problems. At that time the ruling item was "Limits to growth" [10]. Today these academic people have key positions in public service and in industries. This seems to be related to the pillar social surroundings. Colleagues, fellow students, family, societies are a decisive factor whether a signal will be recognised or not [11]. Public opinion depends strongly on opinion makers such as leaders of societies, of trade-unions and even of pressuregroups. These groups are a vital link between their supporters and the government [12]. It is necessary to talk with these "linkgroups" in order to listen what is going on in the public. Only then it is possible to bring an effective message to the public.

The moment a democratic decision has been made, can be seen as a turning point in communication from government with the public. Before the decision is taken only information consisting of facts is acceptable. After the decision, information influencing the people to fulfill the adopted objective is acceptable. Independent thinking people do not like to be pushed to specific conclusions. This behaviour is an international recognized basic principle in the science of communication [13], [14].
Contrary to this principle, the classic approach is: "This is my problem and here is a solution, please give me the necessary budget." The public opinion often doubts about the proposition and ignores the problem sometimes. Only opponents are heard. The policy analysis that was executed to formulate the new policy on erosion control of the Dutch coast was tackled with a non-classic approach [15].

3. CHANCES IN INTERACTION WITH THE PUBLIC OPINION.

3.1. Case Erosion Control of the Dutch Coast.

The erosion of the Dutch North Sea coast (10 millions m3 of sand/year) was a

rather non-recognised problem. The erosion undermined dikes and dunes and caused unsafe situations for the polder areas. About 20 ha dunes/year disappeared by the erosion. That gave the government no reason to allocate a structural budget to fight the erosion. Till 1991 the ruling policy was to solve the most embarrassing bottle necks. The public showed a growing indignation. In 1987 the parliament requested the government to establish a long term policy. The public and the parliament asked for a structural policy. However the government did not want.
The first crucial step to establish the long term policy was a discussion report published in 1989. It gave only facts and alternative policies without preferences. Accompanied by a video-film, some thousands of reports were send to all authorities and persons who might be interested. Since publication of the report the public opinion jumped to the conclusion: "The erosion must be stopped". This was shown by the results of public participation - collected by the Advisory Board of Public Works and Watermanagement. The Minister of Public Works and Watermanagement remained without preference for a specific alternative, so did her officials.
The second crucial step was to contact and to consultate linkgroups. The Royal Institution of Engineers (KIVI) organised a congress for technicians, businespeople, policymakers and politicians. Environmental groups (interested in preserving natural dunes) organised a congress on natural coastal protection. Officials from the Ministry of Public Works and Watermanagement presented only informative speeches. Both congresses lead to the same consensus: Stop the erosion. Others played the role of opinion makers. Consensus was reached too in consultations with provinces, the union of waterboards and other ministries. These bodies were involved in discussions on the drafts for a decisive report choosing the "stop erosion alternative". One major question remained: The Ministry of Finance had to supply the budget.
The third crucial step came by "good" luck. A 5 days lasting storm did heavily damage large duneareas. Emergency measures were necessary. Public was very indignated. That incident breeded a decisive atmosphere. The budget was allocated for the long run.
By the way, the atmosphere for a decision was already reached. All the concerned persons and bodies except the Ministry of Finance, were committed to "stop erosion" before that storm. The linkgroups had done their job well.

The non-preferent attitude of the Ministry of Public Works and Watermanagement until the final decision was very important. Opposition was impossible. The public and every interested group had to plead for "stop erosion"

4.2. Generalization of the approach.

The approach of the erosion control policy of the Dutch coast can be generalized according to the stages in the public opinion [16] and phases of the policy lifecycle (fig. 2). These are linked in table 1. Table 2 shows the more detailed approach interacting with the public opinion. Failing recognition of the problem is supposed. In some cases the phases of recognition and formulation may be integrated if the problem is full recognised.

Stages in public opinion	: Phases in policy lifecycle
a. Discontent.	
b. Crystallization in a common need.	: 1. Recognition. 2. Formulation.
c. Judgment and decision.	: 3. Solution.
	: 4. Management.

Tabel.1. Public opinion and policy lifecycle.

If the government does not permit to publish a report of the phase of recognition,

linkgroups might publish the facts they extract from the discussions. It is important to take time at the end of the phase of recognition. The politicians and the public need time to become familiar with the problem. If there is no reaction, wait for the next chance and continue consequently the existing policy. The facts must do their work.

It is essential to express no preference for a specific alternative in the phase of formulation up to the final decision. A preference opposes the basicprinciple of communication as mentioned in section 2.2. It is essential too to keep in contact with linkgroups and opinionleaders and to involve pressuregroups and

Phase.	Activity.	Who and what.
1. Recognition.	a. Analyze	facts, history, existing policy.
	b. Listen	politicians, press-publications, letters of citizens, linkgroups.
	c. Report	facts, prediction what happens if policy is continued.
	d. Wait	reactions.
2. Formulation.	a. Analyze	alternatives based on reactions, costs, sensitiveness on uncertain predictions.
	b. Test	flexibility of alternatives.
	c. Compare	alternatives.
	d. Report	compared alternatives, NO CHOICE.
	e. Inform	politics, press, linkgroups, scientists.
3. Solution.	a. Listen	participation of public, consultation of linkgroups.
	b. Resume	reactions into conclusions, involvement of linkgroups.
	c. Decide	
	d. Report	decision, execution.
	e. Execute	project, policy.
	f. Inform	see 2e, also schools, universities.
4. Management.	a. Evaluate	results, state of maintenance, costs and budgets, predictions.
	b. Report	involvement of linkgroups.
	c. Inform	see 2e.

Tabel 2. Interacting approach.

governmental bodies in the resuming activities up to the decision. Preferably every consultated body gets success in the consultation phase and there are no losers [17]. Realise that it must be no problem if anyone else adopts your good idea.
The final decision is the responsibility of the government. Also the announcement of the decision to the press must be done by the responsible politician. With the announcement the realization of the project starts.
At the same moment the information about the project goes on. The information intends now to hold public support in order to complete the project and to maintain it afterwards. Special attention should be given to groups who are important in future: Scholars and students. Lectures today help them to remember the project of vital interest in coming decades. The shorter the time of realization of a project is, the shorter the time to loose public support.
Projects whit realization periods taking decades, require flexibility to modify on additional objectives and to go on for the main issue.

Anyhow, during the realization of the project it is indispensable the public feels confidence: This task force guarantees professionality and soberness. Although "Nothing succeeds like success" [18], give true information, also if disappointments occur. Particularly in the long run, telling the truth is a sake for dead or life for confidence of the public. And last but not least: Keep reports simple. Everyone must understand them.

Information goes on in the phase of maintenance to keep the public support awake. In this phase periodic evaluation is necessary. It is difficult for politicians to neglect an evaluation report which concludes to intensivate the maintenance and requires a raise of the budget. When such a report is neglected, public support is indispensable. Linkgroups might seek publicity.
Legal duties to evaluate and to publish the results are useful instruments. Such a legal duty about dike management in the Netherlands is under preparation. This phase remains the most difficult to hold public interest, because sufficient maintenance is never spectacular.

4. FINAL REMARKS.

Public support has to be earned every day again [19]. Of course major public interest, professionality and soberness are necessary issues. Also, the way back to the market: For the public service the public is the market. The recommended attitude is to listen respectfully and to handle patient with the ideas from the public instead of considering them as difficult [20]. Telling the truth is indispensable for confidence. Only simple elements of good behaviour are required. In this way public support can be gained and kept awake.

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The Effects of the Øresund Bridge-Tunnel on the Environment

Les effets sur L'environnement du pont/tunnel traversant le Öresund

Einwirkungen der Brücke-Tunnel-Verbindung über Öresund auf die Umwelt

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SUMMARY

In 1990 comprehensive investigations were made of the environmental consequences of a bridge/tunnel, including the effects on the marine environment in the Baltic Sea and the Øresund. The questions of raw materials, emission, noise, earthquake risk, etc. were similarly investigated. This created the basis for an inter-governmental agreement between Denmark and Sweden on the route and layout of the bridge/tunnel between Copenhagen, Denmark, and Malmö, Sweden.

RÉSUMÉ

En 1990, des investigations générales ont été effectuées des conséquences sur l'environnement d'un pont/tunnel, comprenant les effets sur le milieu marin dans la mer Baltique et de Öresund. Les questions de matières premières, émissions, bruits, risques de séisme etc furent aussi analysées. Ceci créa la base d'un accord inter-gouvernemental entre le Danemark et la Suède sur le tracé et la configuration d'un pont/tunnel entre Copenhaque, Danemark et Malmö, Suède.

ZUSAMMENFASSUNG

1990 wurden umfassende Untersuchungen der Umweltkonsequenzen einer Brücken-Tunnel-Verbindung ausgeführt, einschliesslich die Einwirkungen auf die Meeresumwelt in der Ostsee und im Öresund. Probleme betreffend Rohstoffe, Emission, Lärm, Risiko für Erdbeben u.s.w. wurden ebenfalls untersucht. Diese Untersuchungen haben die Basis für eine interbehördliche Vereinbarung zwischen Dänemark und Schweden über die Linie und den Plan für die Brücken-Tunnel-Verbindung zwischen Kopenhagen, Dänemark und Malmö, Schweden geschaffen.

1. Legislation work

For many years there have been periods when joint Danish-Swedish analyses were made for the purpose of procuring the necessary basis for making a decision on a bridge, a tunnel or a combination of both across the Øresund (the Sound).

In 1990 negotiations were resumed between Denmark and Sweden for a link consisting of a 4-lane motorway and a double-track railway line between Copenhagen and Malmö, Sweden.

In the spring of 1990 the Danish Ministry of Transport and Ministry of the Environment resolved that on the Danish side an assessment should be made of the effects of this link on the environment. The assessment is described in the report "Environment Øresund 1991" (1). Together with a similar assessment of finance, fares policy, company form, etc., of the link the assessments of the report formed the basis for the signing on 23.3.1991 the Danish-Swedish agreement on the construction of the link.
Under the agreement the two countries are bound to begin actual construction work no later than 1993, taking into consideration that

> "design of the link shall take into account what is ecologically motivated, technically feasible and financially reasonable, so that damages to the environment are avoided".

The environmental report "Environment Øresund" does not suggest measures to be taken to protect the environment from the bridge/tunnel across the Øresund but only contains an assessment of the effect on the environment of various designs. This brings the environmental assessment into conformity with the EEC's EIA (Environmental Impact Analysis) Directive.

After the passing of a Danish construction act a number of additional investigations of a technical and environmental nature will be carried out for determination of the detailed construction of the Øresund bridge/tunnel.

A prerequisite for the further work is that construction technique must be environmentally optimized. The invitation for tender and the final contracts with the construction contractors will contain the necessary requirements for ensuring the environmental conditions.

Additional conditions are that a supervising programme shall be established in connection with the construction work in order to record the environmental effects, and that it shall be possible to organize and at any time adjust the construction work so that the environmental effects are minimized.

2. Organization of the preliminary environmental analyses

As mentioned, in 1990 the Danish Ministry of Transport and Ministry of the Environment decided to prepare a preliminary assessment of the effects of the Øresund bridge/tunnel on the environment. The procedure was that a ministerial committee was appointed, consisting of the ministers of transport, environment and defence, respectively. Under this ministerial committee a so-called Øresund committee was appointed, with representatives from the ministries and others, including the Danish State Railways (DSB) and the Road Directorate.

The environmental analyses were carried out with reference to the said committees, and the actual environmental analyses were organized as follows. In an environmental management group consisting of

- construction authority: Ministry of Transport assisted by DSB and the Road Directorate
- environmental authorities: Ministry of Environment, National Agency for Physical Planning, National Agency of Environmental Protection, National Forest and Nature Agency, Ministry of Environment Geological Survey of Denmark, and at a later stage Ministry of Fisheries and the country of Copenhagen

the formulation of the assignments involved in the 10 different environmental analyses were worked out meticulously. This work went on until the middle of 1990, when the contents of the tasks were agreed upon. The formulations of the tasks were then approved by the ministerial committee.

All environmental assessments were to be based on the following technical construction of the link, which had been described in the 1987 and 89 reports. Variants of the route layout might be contemplated. Fig. 1 shows the entire layout, with an alternative route at Drogden.

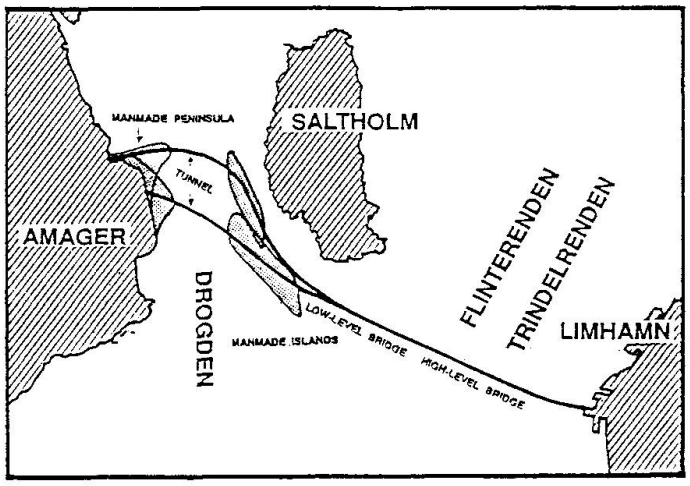

Fig. 1. Routes 1 and 2 for the Øresund bridge/tunnel

The construction in Denmark on land, covering a roughly 12 kilometre long track, follows a route between the centre of Copenhagen and Kastrup, as laid down in earlier reports. The coast-to-coast section consists of a man-made peninsula at Kastrup, from where a 2 kilometre long submerged tunnel continues under the Drogden channel. The submerged tunnel leads to a man-mace island south of the island of Saltholm. From here there will be a 2.25 kilometre long low level bridge, then towards Sweden a 7.5 kilometre long high level bridge section containing two cable stayed bridges with the necessary free span across the Flinderenden and Trindelrenden channels. The coast-to-coast section stretches over a total of 17.6 kilometres.

The 10 environmental assignments were analyses of

- geology, earthquake risk and groundwater conditions
- reclamation of raw materials; localities and their order of priority
- localities for dumping and depositing
- marine environment and biology, both long-term and short-term effects for
  - . oxygen conditions, salinity, and sedimentation layer depths and stability in the remote marine environment, i.e. the Baltic Sea, which is the largest brackish water area in the world
  - . changes in erosion and sedimentation conditions

  - flora and fauna
  - the near marine environment with sedimentation and pollution effects.
- air pollution, including carbon dioxide and nitrogen emission
- birds and seals
- marine archaeology
- noise
- plan descriptions and preservation conditions
- visual environment and architecture

With reference to the environmental management group, which was lead by the Ministry of Transport, these analyses were each carried out with a project manager from DSB/the Road Directorate and a technologically responsible person appointed by the environmental authorities. The analyses were carried out by the construction and environmental authorities' own staff, although firms of consultant engineers and architects were used extensively for especially the marine environment assignment and the visual environment. Experience from the construction of the bridge/tunnel across the Great Belt (Storebælt) was also applied, and staff from A/S Storebæltsforbindelsen, the company responsible for that project, were involved.

The environmental analyses, completed in the last half of 1990 and the first months of 1991, incurred expenditure totalling roughly 10 million DKK.

3. Actual analyses and their results

A summary of the results of the environmental analyses and a comprehensive list of literature are found in the report "Environment Øresund 1991". Danish Ministry of Transport 1991.

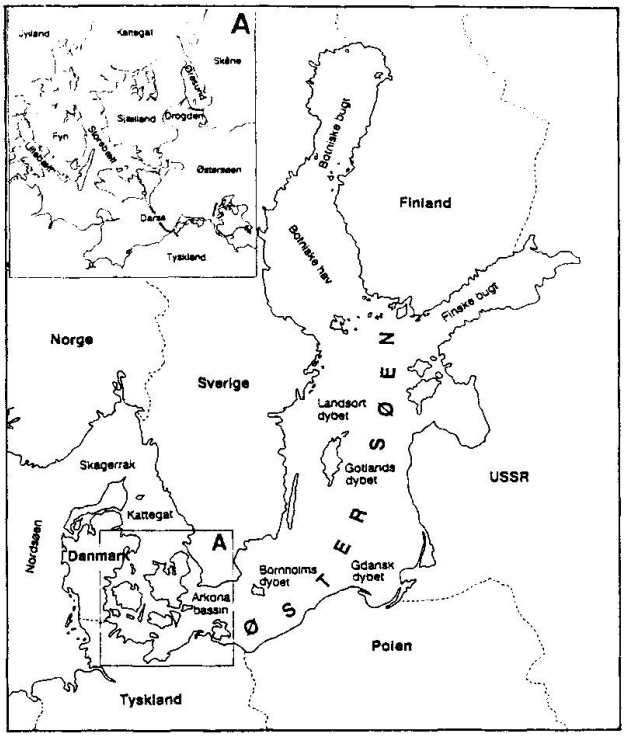

Fig. 2. Map of the Baltic Sea and surrounding territories. The construction area is shown enlarged in the top left corner

Hydrography of the Baltic Sea and the Øresund

Covering an area of 375.000 square kilometres the Baltic Sea is the world's largest brackish water area. It is a very large, deep inlet (Fig. 2), with the Kattegat and the Belts/Øresund as a threshold which impedes the exchange of water between the North Sea/Skagerak and the Baltic Sea. Consequently, changes in the current resistance in the Belts/Øresund will affect the salinity and oxygen conditions in the Baltic Sea.

The exchange of water between the Baltic Sea and the Kattegat/North Sea is primarily governed by atmospherically-conditioned differences in the water levels. In addition, the Baltic Sea is fed some 470 square kilometres of fresh water annually by the rivers. Precipitation and evaporation are practically equal, and therefore the 470 square kilometres of water must leave the Baltic Sea by way of the Øresund and the Belts.

However, differences in atmospheric pressure and forceful westerly winds will cause water movement in and out through the Belts, and the involved water volumes will grossly exceed the said quantity of river water. The exchange of water often appears as cycling flows of about a week's duration. In a normal situation it is estimated that the exchange of water goes through the Little Belt, the Great Belt and the Øresund in the proportion 1:7:3.

A longitudinal section of the Øresund is shown in Fig. 3. It will be seen that the water depth is considerable to the north and to the south but that just by the construction area there is a threshold, the "Drogden Threshold" with depths of some 7 metres. In the deep water areas the volumes of water will most often be in layers, with a lower relatively salt bottom layer and an upper layer with a low density of salt. The division between the two is often fairly sharp, and in the Øresund it normally lies at a depth of 10-13 metres. Thus, in calm periods the salt Kattegat bottom water will be prevented from reaching the Baltic Sea across the mentioned threshold.

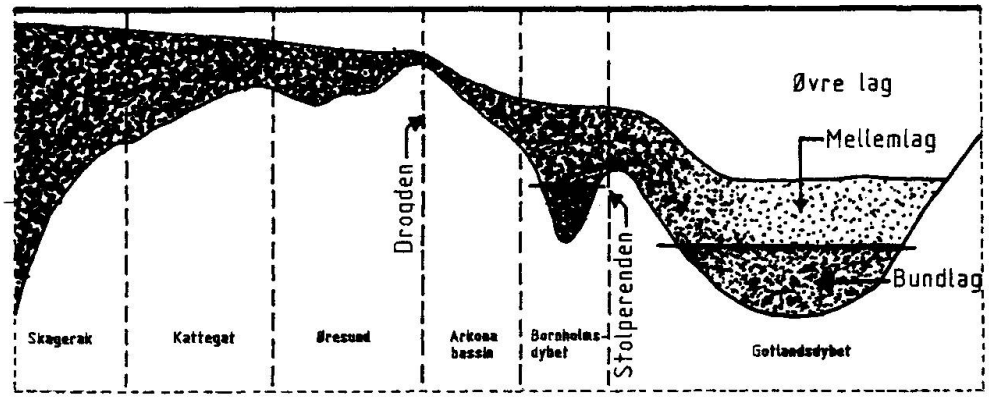

Fig. 3. Longitudinal section of the Øresund

However, during longer periods of southerly current the salt bottom water will be carried across the threshold and into the Baltic Sea. In this connection extremely long periods of violent inflow are of importance. In these cases the volumes of water in the Øresund will gradually become completely mixed, and large volumes of salt water containing oxygen will be carried to the deep basins of the Baltic Sea. It is estimated that these periods of inflow are crucial to life in the deeper parts of the Baltic Sea, but there is disagreement about the importance of the Øresund as compared to the Little Belt and the Great Belt in these extreme situations.

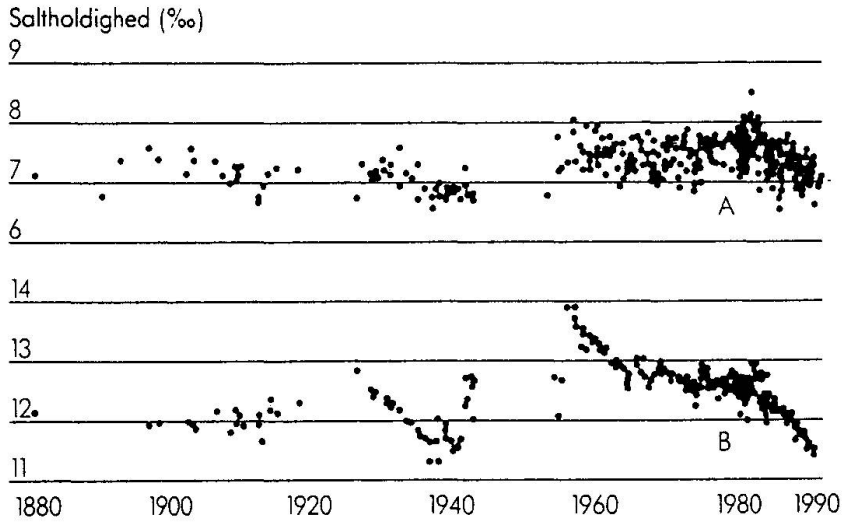

Fig. 4. Variations in salinity 1880-1990 of surface water (top) and bottom water (bottom) in the Gotland Deep.

As said, massive salt water penetration into the Baltic Sea occurs very rarely, most recently in the middle of the 1970s. This may be the reason for a fairly dramatic drop in salinity, especially in the bottom water in the Gotland Deep (Fig. 4). The salinity here has indeed been on the rise through most of the century until 1980. Others have been of the opinion that the change in this salinity should be seen in connection with the pollution of the Baltic Sea, but it should be noted that the salinity at present is not lower than it has been earlier at times when there has been a long interval between two salt penetrations.

Biological conditions in the Øresund and the Baltic Sea

In connection with the environmental investigations the fauna and the vegetation on the bottom of the Øresund in the area around the construction route were mapped.

Fig. 5 shows the distribution of the bottom fauna in the Øresund area. As could be expected the fauna forms a pattern mainly dictated by depth, bottom sediment and salinity.

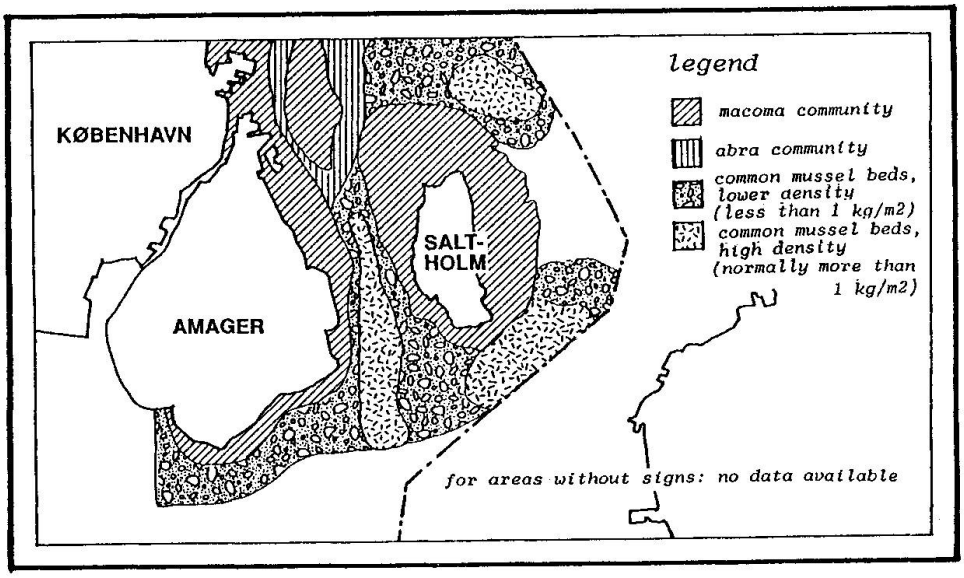

Fig. 5. Bottom fauna distribution near the route of the Øresund link.

All the shown faunas are important to the area's fish and animal life, but the focus here is specially on the areas with continuous beds of common mussels, for these are of great value to the most important bird societies in the area. The Saltholm area is a bird area of international importance. Saltholm houses Northern Europe's largest colony of breeding eiders. There are some 8,000 pairs. The island also contains large populations of breeding gulls and wading birds, and with its mussel beds is of great importance as a resting and foraging area for passing wading birds and for the tufted ducks which winter in the Copenhagen area. Finally, the area is important to the Østersø mute swans, a great number of which seek the area in the moulting period June-September when they cannot fly. The Saltholm area down to sea depths of about 4 metres has been selected as Danish EEC bird protection area No. 110. Another area by the south-east point of Saltholm is protected as a game reserve because of a small population of breeding seals.

Fig. 6 shows the distribution of the major types of vegetation in the area around Saltholm. Here, too, the distribution depends on sea depth and bottom sediment, but also the supply of nutritive salts and the penetration of light at the bottom are of importance to the distribution of the types of vegetation.

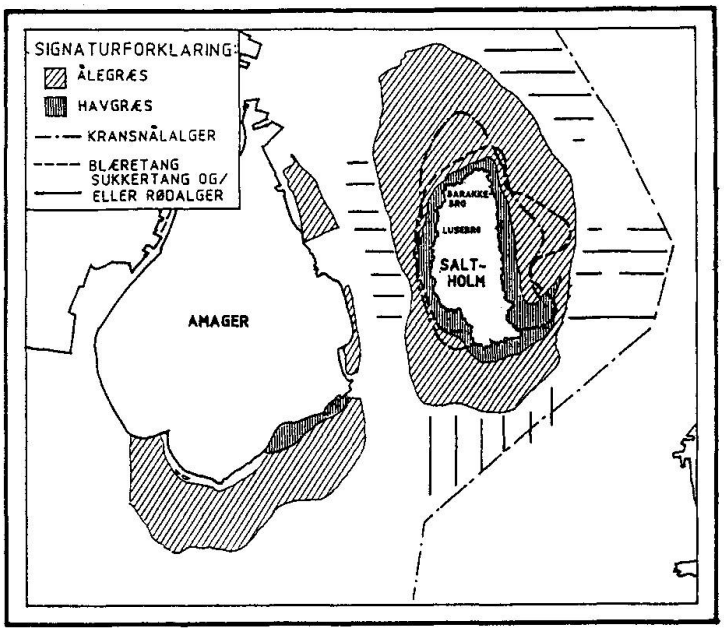

Fig. 6. Distribution of types of vegetation in the area of the bridge/tunnel route.

For certain species of birds and especially for the fish stock the grasswrack areas are considered important. This is because lumpfish and garfish, among others, spawn in the grasswrack, and the grasswrack is home to the fry of eel, cod, herring, garfish and lumpfish. The grasswrack area around Saltholm in Fig. 6 makes up 58% of the entire grasswrack area in the Øresund. It should finally be noted that the Øresund is an important migration passage for, among others, the herring which provides the backbone of Danish fishing of industrial herring in the Kattegat or Skagerak.

Lasting changes in the Øresund and the Baltic Sea as a consequence of the bridge/-tunnel link without compensatory removal of earth

Assessment of the effects of the Øresund bridge/tunnel were based on model calculations, in some cases supplemented by estimates. Two hydro-dynamic models were made, based on the DHI model systems MIKE 21 and MIKE 12. The former is a two-dimensional one-layer model, the latter a two-layer model with one dimension.

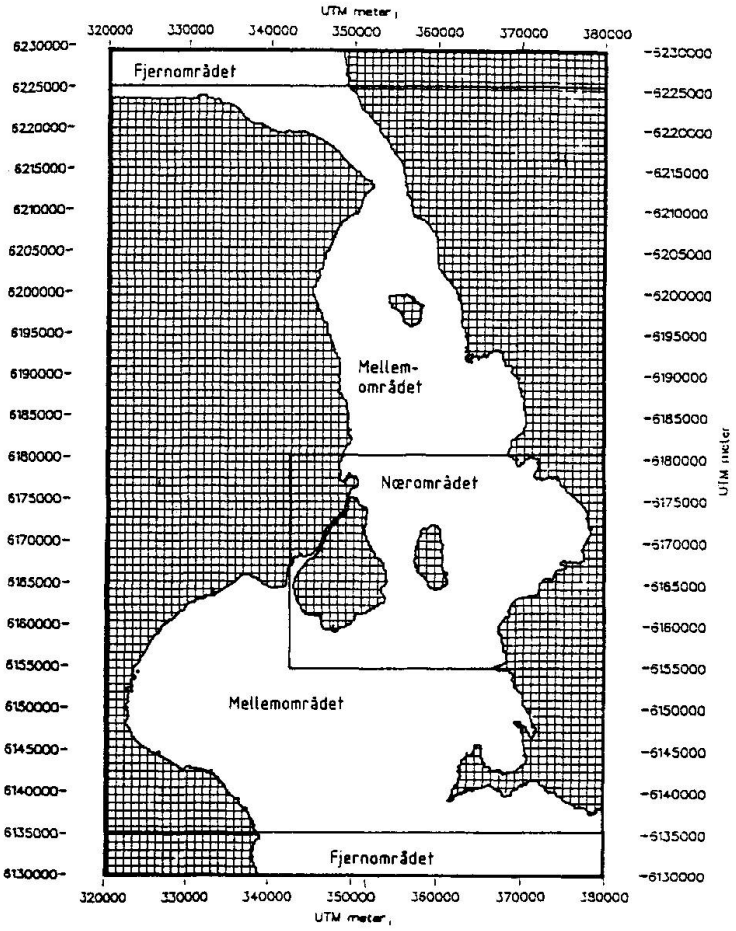

Fig. 7. Division between near, medium distance and remote areas in the models.

The near area (Fig. 7) was assessed with MIKE 21, and a 250 metre grid in the topographical database was used.

The medium distance area (Fig. 7) was modelled with both types of model, the selection of each investigation parameter being based on resource requirements and necessary degree of detail. As a topographical background for MIKE 12 a grid of 1000 metres was used.

The remote area was assessed with a special Baltic Sea model.

As the result of the assessments the following lasting effects can be pointed out:

The bridge/tunnel without compensatory removal of earth will increase resistance to the current in the Øresund by 2-3%. This will lead to a reduced through-flow of water and therefore to reduced salinity and oxygen content in the Baltic Sea. However, the model calculations only indicate a very small reduction, as shown in Fig. 8. The reduction is small whether route 1 or route 2 across the Drogden channel is chosen, and it is expected that it can be made smaller by adjusting the design of certain details of the construction in the projection phase. Finally, it should be noted that the effects in the Baltic Sea from the Øresund bridge/tunnel are of the same magnitude as the uncertainty of the 0 solution for the bridge/tunnel across the Great Belt, which is now under construction.

Conditions	Route	Salinity upper layer %	Salinity bottom layer %	Division level depth Metres	Division level stability %	Oxygen supply bottom layer %
Without CM 4.2 Present situation		0.770	1.330	49.77	100	100
With CM 4.2 after flat area earth removal	1	0.770	1.330	49.77	100	100
With CM 4.2 after channel deepening	1	0.770	1.332	49.80	100.15	99.70
With CM 4.2 without compensatory earth removal	1	0.768	1.329	49.80	100.06	99.63
With CM 4.2 without compensatory earth removal	2	0.767	1.328	49.81	100.05	99.47

Fig. 8. Key figures for effects of Øresund bridge/tunnel with and without compensatory earth removal

Fig. 9 demonstrates that brackish water areas generally contain fewer species than fresh and salt water areas. Considering that the salinity of the Baltic Sea is about 1.3% in the bottom water and 0.7-0.8% in the surface water, it can be deduced from Fig. 9 that reduction of the salinity will lead to a reduction in the number of species. The following sections will describe that the reduction in salinity in the Baltic Sea as a consequence of the construction of the Øresund bridge/tunnel without compensatory earth removal will be very moderate, but at the same time it should be noted that there is uncertainty about the assessment of the effect that this minimal reduction will have on the distribution limits of the species in the very sensitive Baltic Sea. Particular fear has been expressed that the distribution limits for the cod in the Baltic Sea will be disturbed by the effects of the construction. Nonetheless, changes in the salinity should still be seen in connection with the natural changes registered in the Baltic Sea, see Fig. 4.

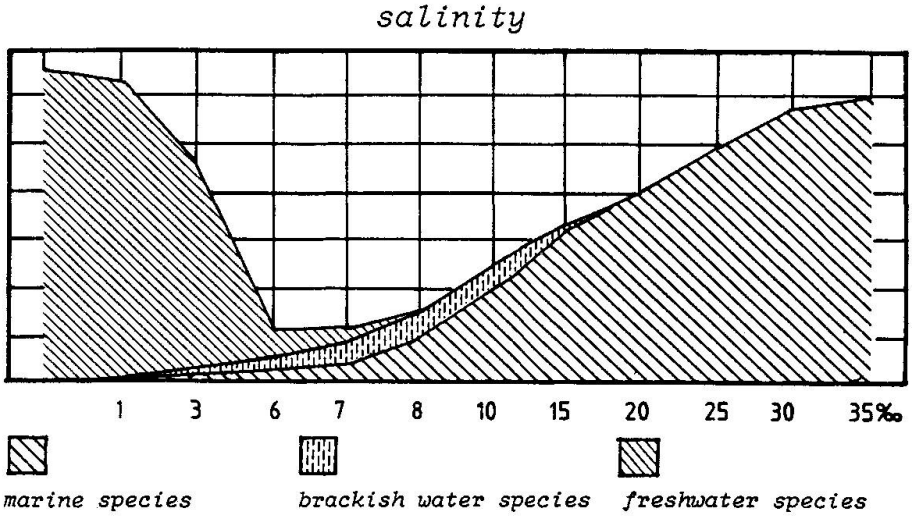

Fig. 9. Relations between number of macroscopic animal species and salinity in a normal sea area.

In the Øresund the man-made island and peninsula cover an area of roughly 3 square kilometres. Part of this area today is common mussel beds and grasswrack meadows.

In the area south of Drogden it is expected that the salt balance will be changed moderately whether the bridge/tunnel is built with or without carrying out compensatory earth removal.

The models were not used for showing effects in the near environment of the construction without compensatory earth removal, but qualified assessments point to the following effects:

* The velocity of the current in the Drogden channel will be slightly increased.
* In the area by the root of the man-made peninsula conditions will become calmer, and the result will be a bottom sediment of more organic content and consequent risk of unpleasant smell in the area.
* Ice conditions in the area will be altered. West and partly south of the man-made island and between this and Saltholm an ice sheet will form more rapidly and stay longer in cold winters. An increased frequency in episodes of pack ice must also be foreseen.
* There will be a great risk that the channel between Saltholm and the man-made island will sand up so that periodical dredging will be necessary. If neglected it will be difficult to prevent foxes and rats from reaching Saltholm, and this will be damage the bird life.
* The small population of seals at the south-east point of Saltholm will probably disappear.
* The number of moulting swans in the area will possible be reduced.

Compensation possibilities

If it is desired to entirely remove or to reduce the described effects of the construction on the Baltic Sea, this is possible. One can choose to remove earth from the bottom in the area around the route. This solution will ensure unaltered flow through the Øresund. The necessary volume of removed material will depend on whether route 1 or route 2 is selected, and on the tunnel length and depth to the tunnel top. Fig. 10 gives an idea about necessary volumes to be removed by the investigated construction of route 1 and by various lengths and depths for route 2. Locations of the removals are shown in Fig. 11.

		Length		
Route	Level for top side of tunnel	1800 metres	2000 metres	2400 metres
1	- 10 metres	9.2	-	-
2	- 10 metres	14.5	12.1	15.5
2	- 11 metres	11.5	9.0	-
2	- 12 metres	9.3	-	-

Fig. 10. Volumes, in millions of cubic metres, necessary to be removed for full compensation for effects of the construction on salinity and oxygen contents in the Baltic Sea by route 1 and by various lengths and depths for the submerged tunnel in route 2.

Another possibility is to deepen the channel. By expanding channels and making moderate deepenings totalling about 1.3 million (route 1) or 1.65 million cubic

metres (route 2) in the areas shown in Fig. 10, unaltered salinity in the Baltic Sea can be achieved. However, the water through-flow and thereby the contents of oxygen in the Baltic will be reduced slightly (about 0.3%) by the bridge/tunnel after channel deepenings.

Temporary effects in the Øresund caused by the bridge/tunnel

Temporary effects in the Øresund depend a great deal on the waste from foundation digging and possible compensatory removal of flat area earth. If it proves possible to keep this waste down to 5% the investigations predict only relatively moderate temporary effects as follows:

* Some reductions in the bio-mass for both fauna and vegetation may be caused by a cover of sediment and by the light being temporarily reduced by sediment vanes and algae. But the analyses do not point to significant reductions in fauna and vegetation if waste is kept within the target percentage.
* Some of the waste sediment will consume oxygen. It is, however, estimated that the increase in oxygen consumption will be so moderate that it cannot in itself cause occurrences of lack of oxygen but perhaps aggravate already occurred lacks of oxygen.
* Algae may flourish because of increased quantities of nutritive salts in the water emanating from waste sediments containing nutritive salts. However, the analyses indicate that it will be a question of relocation of these areas of water with increased nutritive salt contents rather than an extension of the areas.
* Waste of sediment containing heavy metal. With the actual knowledge of the earth type distribution in the area it is expected that the waste sediment will contain a smaller proportion of heavy metal than the present bottom sediment.

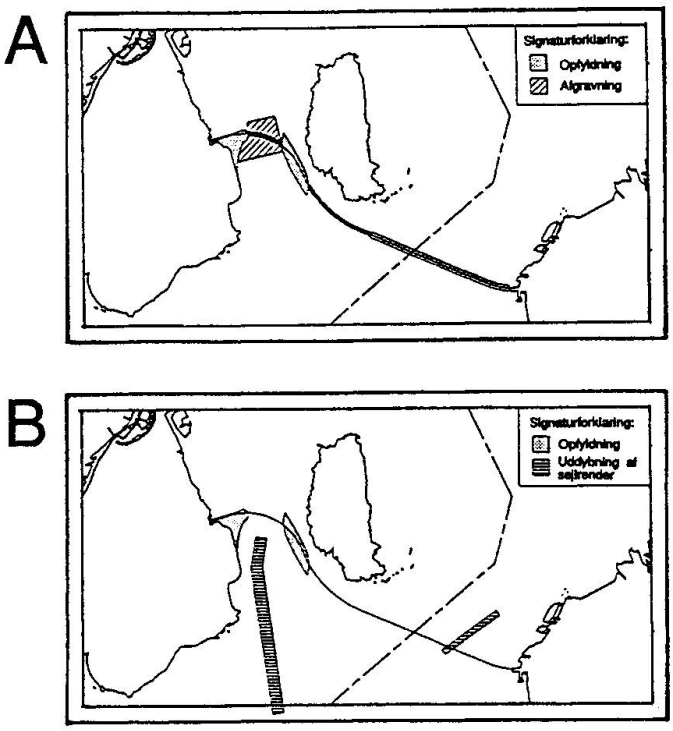

Fig. 11. Localization of earth removals when deepening flat area and channel respectively.

In all circumstances the danger of serious effects from the digging will be increased in step with the extension of the digging, i.e. in proportion with the size of the chosen compensatory removals of earth.

Other investigations

Besides the analyses of the effects of the bridge/tunnel on the marine environment, assessments have been carried out of the geological situation in the area, of noise and emission consequences of traffic across the bridge/tunnel, and of possible conflicts between the bridge/tunnel and marine-archaeological interests. Finally, a series of preliminary reflections have been made on the architectonic design of the construction.

The geological analyses included assessments of the bearing strength and diggability of the various types of earth in relation to foundation digging and possible compensatory removals of earth, of raw material reclamation prospects, of groundwater problems as a consequence of the constructions on land in Denmark, and of earthquake risks, if any, to the bridge/tunnel.

Summarily it can be concluded that none of the investigations carried out has lead to results which in any way suggest that the bridge/tunnel will be a serious strain on the environment in the area.