# THE MANAGEMENT OF MARINE HABITAT

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### Abstract

The management of marine habitat involves issues that are chemical, biological and physical in nature. The variety of impacts and the complexity of marine ecosystems presents special challenges to habitat managers and calls for careful attention to management functions and institutions. Canada adopted a new approach to habitat management in 1986, elements of which are discussed in this paper. The main features of this policy relate to the objective of overall net gain in productive capacity and how this is achieved through conservation (no net loss principle), restoration and development. Models that quantify these principles and thus provide targets for management are only now appearing, examples of which are given for aquaculture sites. These represent a good starting point for the development of more comprehensive views of the ecosystem both in relation to aquaculture and elsewhere.

An extensive set of regulatory measures has been established to provide managers with the tools to manage habitat development towards the objectives. However, in the case of the offshore marine environment particularly, much needs to be done to ensure the long-term monitoring of human impacts on the habitat. Recent initiatives in this are presented. Current efforts to integrate the disparate data bases used in support of habitat decision-making are also discussed. The paper ends with a description of the consultative process used by Canada to review proposals that have potential habitat impacts.

### Introduction

In Canada, as in other parts of the world, marine habitat problems can be considered under three broad categories. Chemical issues involve the impacts of oil spills, both from rigs and vessels, and exploration. The ocean dumping of chemical waste can be considered under this category. The second set of issues are biological in nature, generally involving the effects of eutrophication on coastal waters, resulting from runoff of agricultural land, sewage from urban areas and industrial waste from fish processing, fertiliser plants and even aquaculture. For instance, there has been much discussion in Europe on the linkage between human-generated eutrophication and phenomena such as red tide and the incidence of Phocine Distemper Virus (Ross *et al.* 1992).

Finally, there are the impacts of physical structures on the habitat. These include barriers (Canso Causeway, link to Prince Edward Island, dam for Fundy Tidal Power), marine debris (plastics, discarded nets which can "ghost-fish") and disruption of the benthos (ocean mining, fishing gear impacts on bottom, laying of cables and pipelines, etc). A number of these are detailed in Messieh *et al.* (1991).

All these issues are common to most parts of the industrialised world and have elicited various management activities as and when they arise. However, to be truly effective, the response of managers to habitat issues *must* be based on a system which has well defined goals, regulations and monitoring activity. Otherwise one runs the risk of a patchwork approach to habitat management.

In 1986, Canada adopted a new approach to habitat management, after an extensive period of consultation. In this paper, I will discuss the main elements of the current policy and its implementation. As well, problem areas will be identified together with some of the current programs that are underway to address these.

## The management unit

Any discussion on the management of habitat—marine or otherwise—must start with a definition of habitat. In the Canadian Fisheries Act, habitat is defined as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes". Thus, it is that part of the ecosystem, including the biotic and abiotic components, upon which a fish depends. The Act is silent on the issue of the importance, commercial or recreational, of the fisheries and indeed is broad enough to include the entire ecosystem. In recent years however, the management of fish habitat has been directed towards those species that are economically or socially important to Canadians. It is becoming increasingly evident that many user groups are interested in access to the marine environment, most notably tourist interests, and there is growing concern that degradation of marine habitat will, in the long term, have negative impacts on other parts of the environment. It is evident then that as the use of habitat evolves, so too will the focus of its management. Current Canadian legislation appears flexible enough to accommodate this. In addition, as with fisheries management, it is important to keep in perspective the economic and social consequences of habitat degradation, and thus its management, on the human population.

Given that habitat management can be considered synonymous with ecosystem management, it is easy to understand why it has been so very difficult to undertake. In fisheries, the focus of management is the biological stock. This considerably simplifies the situation in relation to goal setting, regulation and monitoring. With habitat, on the other hand, even defining the ecosystem is not a trivial matter. Nevertheless, it is axiomatic that in order to effectively manage, the first step is to define the boundaries of the "management unit". Too often, this has been given little consideration in the definition of habitat management systems.

Off Nova Scotia, progress has been made on the preliminary identification of a number of ecosystems (Mahon and Sandeman 1985). The Gulf of Maine ecosystem, characterised by a mixture of warm and cold water species, stretches from Cape Cod to midway up the Scotian Shelf (Figure 1). The Laurentian Ecosystem continues from there, across the Laurentian Channel along the southern coast of Newfoundland to meet the Labrador Ecosystem which continues north up the Labrador Shelf. The boundaries of these ecosystems tend to coincide with major physical oceanographic features present on the coast, lending support to the hypothesis that the productivity of these communities is largely related to the prevalent environmental conditions.

As yet, those ecosystem boundaries have not been used to assist in the management of offshore habitats as more work is required to confirm and refine the integrity of these units (Mahon *et al.* 1984). Nevertheless, habitat managers will have to be aware of the characteristics of the ecosystem with which they are dealing. Definitions of characteristics, such as the ones presented, are a useful first step in this regard.

## The goals of habitat management

Management goals can be considered as being composed of objectives which define what it is that one wants to achieve, and strategies which are quantifiable targets or constraints by which one measures the success (or otherwise) of management.

In Canada, the long-term objective is the achievement of an overall net gain in the productive capacity of fish habitats (Anon. 1986). This is considered to be possible for anadromous and certain freshwater and shellfish species but more limited in marine ecosystems. Nevertheless, the long-term thrust of the policy is to regain habitat to compensate that which has already been lost.

This objective is achieved through three initiatives:

1. **Conservation**—Maintain the current productive capacity of fish habitats supporting Canada's Fisheries resources, so that fish suitable for human consumption may be produced. This strategy is synonymous with the No Net Loss Principle.
2. **Restoration**—Rehabilitate the productive capacity of fish habitats in selected areas where economic or social benefits can be achieved through the fisheries resources. This is to correct past mistakes (ie installation of dams without fish passages, sewage treatment plants, etc).
3. **Development**—Create and improve and generally enhance fish habitats in selected areas where the production of fisheries resources can be increased for the social or economic benefit of Canadians.

The combination of conservation, restoration and development initiatives leads to a net gain in overall habitat productivity. While this is simple in concept, it does not help unless we have targets and constraints by which we can define and measure levels of conservation, restoration and development.

In fisheries management, mathematical formulations called strategic models, such as Surplus Production and Dynamic Pool models (O'Boyle 1987), have been used to define targets and constraints on harvesting such as Maximum Sustainable Yield, $F_{MAX}$ and minimum Spawning Stock Biomass.

These models summarise our knowledge of the dynamics of marine populations and provide understanding on the impacts of harvesting on yield, recruitment, population growth and abundance and so on. They thus provide the means to quantify overfishing, and therefore provide guidance for the control of harvesting levels.

Development of strategic models with the ensuing targets/constraints for habitat management, is not as advanced as for fisheries management. There is an urgent need for these, given the rapidly growing encroachment on habitat that is occurring around the world. Given the complexities of the ecosystem it is understandable that model development has been slow. This is not to say that there has not been progress. Gordon (1992) for instance, reviews a number of significant efforts in the North Atlantic. Much more is still required. There may be a temptation to resist model development until more data are collected. This would be a mistake. Silvert (in press) shows that it is important to create models, based on first principles and simple assumptions now, that can be updated as more is learned about the system in question. Through the constant interaction between field and model, understanding of the cause and effect of habitat management can be dramatically improved.

Silvert (in press) illustrates how simplified models can be constructed to evaluate the impacts of salmon aquaculture sites on habitat. As with fisheries models, the impacts can be evaluated at various levels. This is an important consideration in that it partitions the overall problem into smaller, more manageable units and is perhaps an approach that could be adopted for other habitat problems.

The first level that he considered was at the inlet or regional scale. He described total acceptable bay production as a function of depth, flushing time, nitrogen production and the capacity of the bay to handle this production, or

$$\text{Maximum Production per Unit Area} = f\left(\frac{\text{Depth}}{\text{Flushing Time}}\right)\left(\frac{\text{Nitrogen Load Limit}}{\text{Nitrogen Production}}\right)$$

All these parameters are measurable or can be derived from previous studies. The maximum aquaculture production allowed in the bay that maintains *conservation* of the habitat can then be calculated.

The next level considered was at the local scale involving inter-site impacts and is therefore concerned with placement of aquaculture sites within the inlet. At this scale the localised effects of benthic disposition are important, which can be mitigated against by defining a minimum site depth for a particular size and level of site productivity. Silvert (in press) describes the minimum allowable site depth as a complex function of total production, settling speed, aquatic transport and bottom type. Again, the manager can then judge the appropriateness of a particular cage site at a given depth.

The last scale to consider is at the internal or cage level where oxygen depletion within the cage site itself must be considered. Here, the size of the farm is related to its production capability, or

$$\frac{\text{Maximum Production}}{\text{Length of Site}} = f\left(\frac{\text{Current Speed} \times \text{Depth}}{\text{Oxygen Consumption}}\right) \times \left(\text{Ambient Oxygen Level} - \text{Lowest Acceptable Oxygen Level}\right)$$

Thus, the physical dimensions of the farm can be modified to be compatible with the existing environmental conditions.

At present, while there is recognition that these levels interact, little has been done to quantify this. This is an important area of study. There may be a tendency in the evaluation of small, localised development proposals to grant approval where effects are too small to measure. Over the long term, the cumulative effects of this process will be felt. Thus there is real benefit to providing a means of measuring and assessing this incrementalism.

The above models were formulated for aquaculture applications and are at an early stage of development. There is a need to develop models for other areas of habitat usage so that managers can be provided with quantitative measures of conservation, restoration and development.

## The controls of habitat management

There are two aspects of control—regulation to ensure that habitat developments are consistent with the goals of management, and monitoring to ensure that the regulations are having the desired effect. The monitoring activity may lead not only to changes in the regulations but also, through scientific research, to modifications in the strategic models.

### *Regulation*

When a development proposal is received by the Canadian Department of Fisheries and Oceans (DFO), a hierarchy of regulatory measures is used to ensure attainment of the conservation (no net loss) objective:

1. The natural productive capacity must be maintained through redesign of the proposal, location of the project at alternate sites and, in the case of chemicals, pollution control devices. If this is not possible (for other than liquid waste discharges) then,
2. Compensatory options are pursued, including like-for-like habitat on the same site, like-for-like habitat at an alternate site or finally enhancement of the productivity of the existing habitat. If these options are not possible; then,
3. Artificial production may be considered as long as the objectives of local fisheries are observed and the methodology is practical and proven.

There is a considerable package of legislation (Anon. 1991) which provides the enforcement tools of regulation including fines, the requirements for safe fish passage, minimum flow requirements, fish-way protection, physical disruption of the habitat and its pollution. Most of these regulations are more relevant to the inland and coastal waterways but can be extended to the marine environment as required.

There are a number of reporting requirements in the Canadian Habitat legislation that are of importance. Besides the ongoing requirements, it is the responsibility of the developer to provide the analyses of potential impacts of the development on the habitat. This will be discussed further below.

### *Monitoring*

For the marine habitat, most of the monitoring effort has been conducted close inshore. For instance, there is an extensive network of monitoring sites to evaluate levels of coastal phytoplankton, with the focus on those capable of producing phytotoxins. Over the long term, this information will be useful in evaluating whether or not these events are related to anthropomorphic trends. For instance, it has been proposed that the mass mortality of harbour seals in Europe in 1988, caused by Phocine Distemper Virus, might be related to the levels of immunosuppressive pollutants (Ross *et al.* 1992).

In the offshore area, while effects of bottom disturbance have been documented (Messieh *et al.* 1991), there has been no long-term program in place to track decadal scale changes. However, as a consequence of consultations conducted in 1989 (Hache 1989), a program has been established to evaluate the impact of trawling on the benthic habitat. Thus far, the project has focused on the development of gear capable of sampling the bottom, including side-scan sonar mounted on a towed vehicle, epibenthic sled equipped with video camera and hydraulic-powered, video-equipped bottom grab (O'Boyle *et al.* in press). This project will use the opportunity provided by areas closed to fishing activity to investigate the impacts of fish trawling on the benthos, similar to the studies conducted by Sainsbury (1991). In the longer term, it may be possible to integrate this benthic monitoring activity with annual groundfish trawl surveys.

An important aspect of monitoring is, as stated earlier, the provision of a decision-making facility to managers to assist in the initial review of development proposals and their ensuing impacts. In fisheries, extensive information systems have been developed to provide the necessary input to management. Comparable systems are only now being developed for habitat applications.

One of these is being developed as part of a project, on the L'Etang estuary in southwest New Brunswick, to provide the basis of the evaluation of the suitability of aquaculture sites. The work of Silvert (in press) and Silvert *et al.* (1990), mentioned earlier, is part of this project.

The structure of the decision-making system currently under development is presented in Figure 2 (Keizer, pers. comm.). The central feature of the system is a GIS-based analysis package. This package can access a number of data bases, ranging from human activity to fisheries statistics, available in a number of different organisations and locations, and allow the collation of disparate data over different spatial scales. Interestingly, this requirement, driven by the complexity of habitat issues, has called for the definition of computer communication standards, policies on access to data bases, and consideration of institutional arrangements to facilitate data sharing.

On the other side of the GIS are decision-making models which would be unique for each habitat issue. For aquaculture, these models would allow the manager to survey all information relevant to a specific locale under consideration for site placement, as well as accessing other models available to evaluate impacts. Initially, the system may only be a pointer to these models but in the future it will allow options investigation by the decision maker.

It is envisaged that this information system will become a key component of the evaluation process for habitat proposals. Nonetheless, while the system will provide the necessary technical backup, an extensive consultative process is also required to evaluate habitat-related proposals. Experience has shown with other management systems that consultation is a key element that requires careful consideration (O'Boyle submitted).

## The consultative process

The process used by Canada to evaluate development proposals is given in Figure 3. All Canadian federal government departments are required to conduct evaluations for projects under their jurisdiction as part of what is referred to as the Environmental Assessment Review Process (EARP). The initial information and evaluation report (Environmental Impact Statement) prepared by the project proponent is received by the DFO Habitat Management Branch for their evaluation. A considerable consultation process now commences during which the potential biological, chemical and physical impacts of the project are assessed. It is during this phase that the objectives of conservation, restoration and development are assessed. Until recently, regional scientists had to undertake these evaluations. In 1992, the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) struck a new subcommittee on habitat to serve as a scientific peer review forum on habitat issues. This pooling of scientific expertise to consider resource issues has been central to the success of other management agencies such as North Atlantic Fisheries Organisation (NAFO), International Council for the Exploration of the Sea (ICES), Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) and International Commission for the Conservation of Atlantic Tunas (ICCAT), and will greatly facilitate efforts to provide informed advice on habitat management.

This process can either lead to further public consultations (major impacts projected) or more limited consultation with the immediate proponents (minor impacts projected). If public consultation is required, the Minister of Fisheries and Oceans recommends to the Minister responsible for the Federal Environmental Assessment Review Office (FEARO) that a public review panel be appointed. The latter is a nonpartisan board of experts to which DFO and the proponents, as well as the general public, make submissions. This board then considers the input and makes a recommendation to the Minister. The proponent can appeal this decision directly to the Minister. Ultimately the latter makes the final, binding decision.

While this process is involved, it has worked relatively effectively in decision-making on habitat issues.

## Concluding remarks

The management of Marine Habitat is complicated by the scale of the problem and complexity of ecosystems. However, this enforces the need for a structured approach to management involving consideration of the management units, objectives, targets, regulations, monitoring and consultative processes. Canada has made significant progress in establishing a management policy, regulatory framework and consultative process to guide its management of habitat. Considerable work is still required to define models of the cause and effect of impacts as well as to establish effective monitoring systems. Work in these areas has been initiated and will require a sustained effort to ensure the realisation of an effective system for marine habitat management.

## Acknowledgements

The author gratefully appreciates the input and review comments received from Don Gordon, Bill Silvert, Paul Keizer and Dave Marantz.

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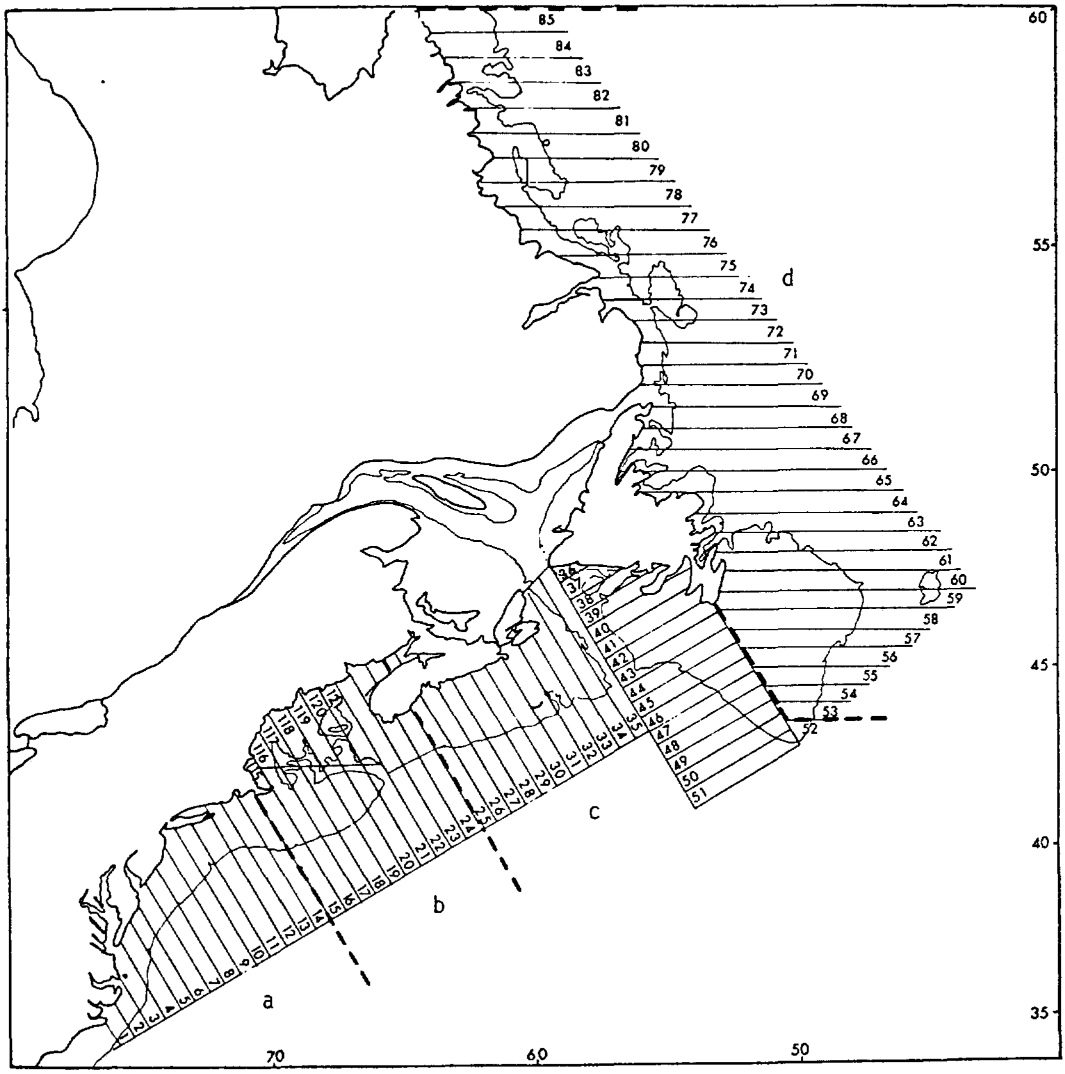


**Figure 1.** The four major clusters of bands using the occurrence of fishes at depths of 50-200 m to identify the marine ecosystems off the Canadian East Coast; a) New England; b) Gulf of Maine; c) Laurentian; and d) Labrador. (from Mahon and Sandeman 1985).

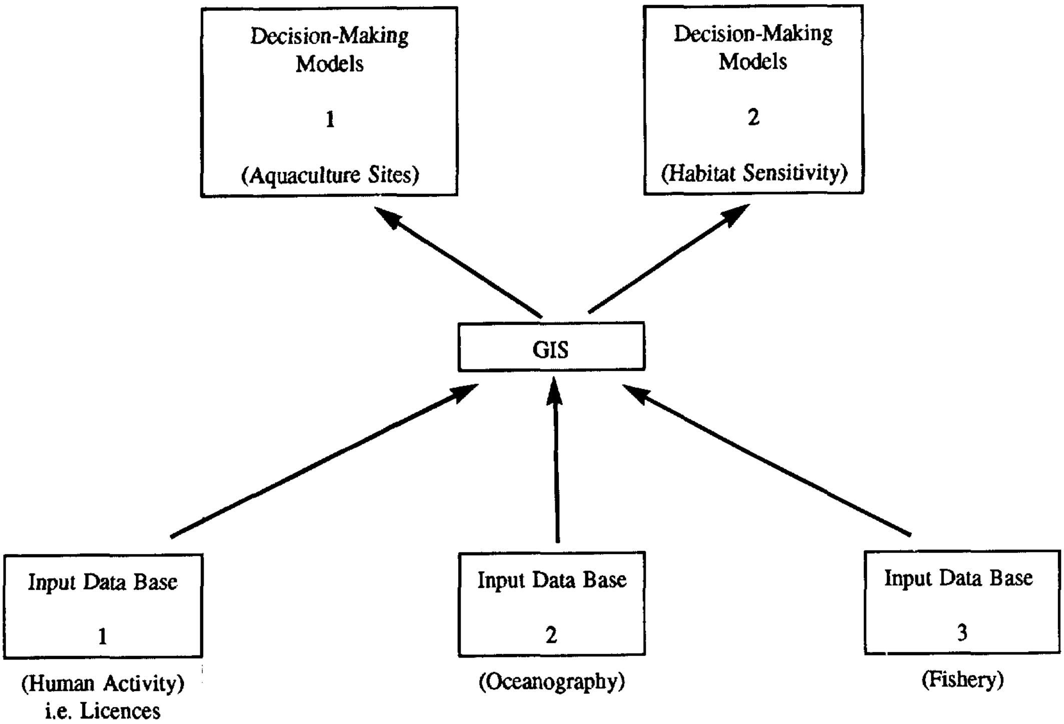


**Figure 2.** Relationship among input and decision-making data bases and GIS (Geographical Information Systems) developed as a decision-making system for the L'Etang Estuary Project.

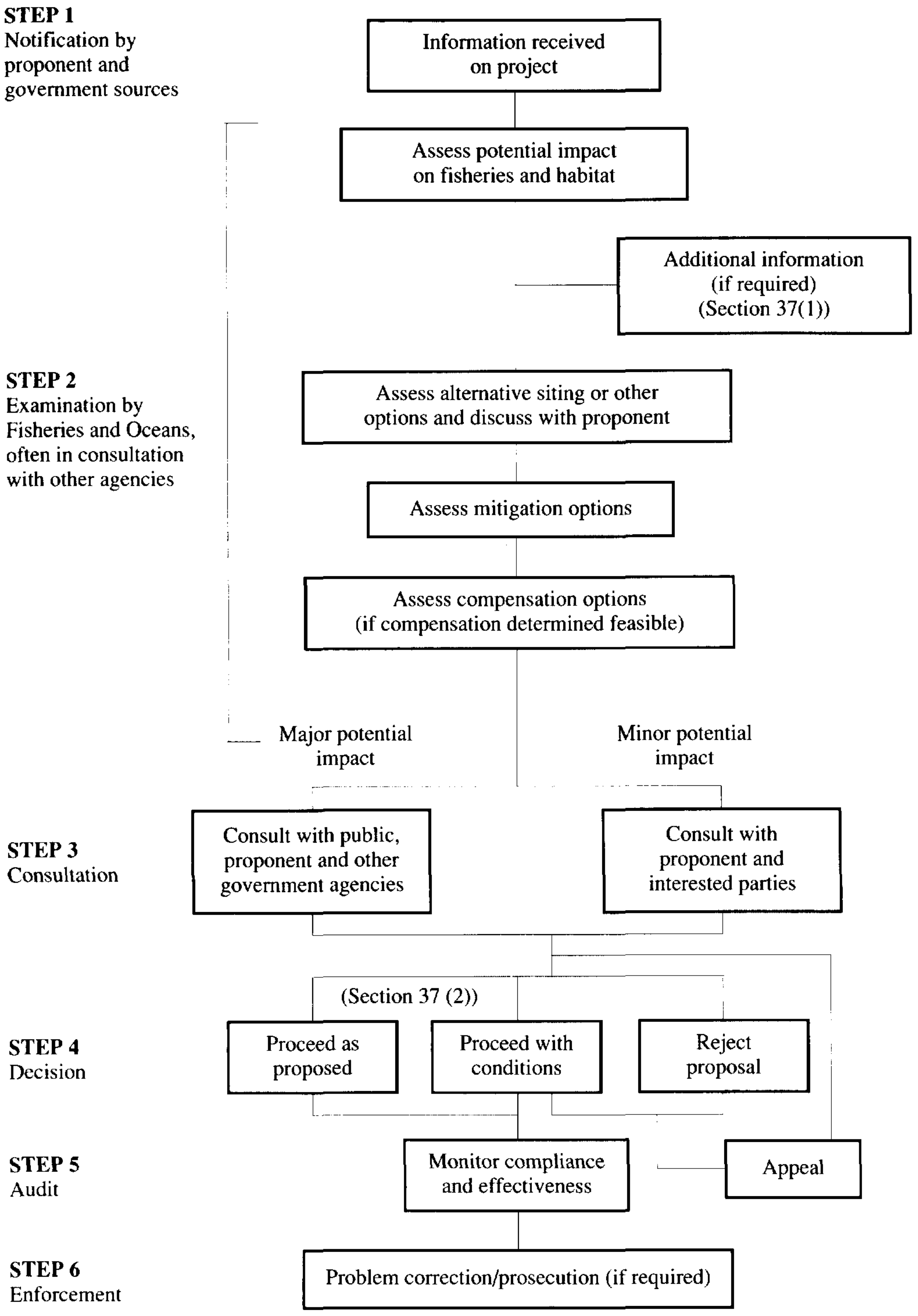


**Figure 3.** Procedural steps to achieve No Net Loss (from Anon. 1986).