POLLUTION AND WATER QUALITY CONTROL OF THE RIVER TEJO

Report on a visit to Portugal
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CONTENTS

1. Purpose of the Mission

1) To advise on the role of biology in the proposed Administracaos de Regiao Hidrografica (ARH).

2) To establish priorities for biological studies within the present Projecto de Gestao Integrada dos Recursos Hidricos da Bacia Hidrografica do Rio Tejo (PGIRH/T).

3) To assist with the planning of laboratory facilities for biology at the new PGIRH/T laboratory at Alges, Lisboa.

2. Project Area

Fundamental changes in the management of water resources in Portugal are now evolving. These are based upon concepts elaborated by Veiga da Cunha et al. [1,2] and accepted by the Portugese Association of Water Resources. The principles of the new management philosophy were outlined by Nunes Correia [3] and summarised in an English translation by O'Kane [4].

In brief five regional organisations termed Administracaos de Regiao Hidrographic (ARH), will be created to manage water resources within their respective geographical areas. These areas will be catchment based. They will be expected to interact effectively with both central government and also the municipal authorities and associations of water users who will variously bear responsibility for the supply, treatment and disposal of water for domestic, industrial and agricultural purposes.

These new ARH's will be expected to operate within a framework of legislation which will be implemented on the basis of the polluter-pay principle [5].

As a fore-runner to the implementation of the five ARH's a foundation project has been established within the Direçcao-Geral do Recursos Naturais to examine the practical implications of the new system. This project has been divided into a number of sub-projects and complementary projects to include the Tejo complementary project.

The Tejo complementary project, which is the focus of this report, is also termed the Projecto de Gestao Integrada dos Recursos Hidricos da Bacia Hidrografica do Rio Tejo (PGIRH/T). It is an administative unit of the Direçcao-Geral da Qualidade do Ambiente (DGQA). A similar complementary project has been set up in the North of Portugal, the PGIRH/Norte.

The present PGIRH/T project integrates the objectives of two other projects partly funded by WHO. These were UNDP/UNESCO/WHO project "An Environmental Study of the Tagus Estuary" (POR/77/016) which was concluded in 1984 [6] and "Pollution and Water Quality Control of the River Tejo (POR/80/001) [7] whose title and project code have been retained. It draws to a large extent on their personnel and technical expertise.

Indications of the objectives and organisation of biological studies in the Tejo catchment are given in earlier consultant reports [4, 8, 9].

3. Findings

3.1 The conceptual role of biology in ARH's

The central objective of the ARH's should be to best manage the water resources of their respective catchments through cognizance of both the various demands for those resources and the legislation and directives of both Portugal and of the European Economic Community [10].

They should pay due regard to the quality and quantity of both surface and ground waters in relation to domestic, industrial and agricultural usage and to the needs of recreation and conservation. In particular they should ensure that water returned to the system by users should be of sufficient quality and quantity that its further uses, for whatever purposes, are not impaired.

The quality and quantity of water needed to sustain aquatic life should, wherever possible, be one of the guiding objectives, in conjunction with the needs for potable supply, and for bathing and other recreational activity.

The principles of protection of aquatic life are detailed in European Economic Community (EEC) directives L4129, "Directive on the discharge of dangerous substances" [11]; L222, "Directive on fishing water quality [12] and L281 "Directive on quality of water for shellfish growth" [13].

Directive L4129 applies to the whole of the aquatic environment of the EEC including inland rivers and lakes, coastal waters and territorial seas. It asks member states to eliminate pollution caused by certain proscribed "black list" substances [11], and requires each state to set its own limit values for these substances based on their toxicity, permanence and bioaccumulative character [10]. Discharges should always be concentred to ensure limit values are not exceeded.

Directive L222, on fishing waters, refers exclusively to fresh waters whilst L281, on shellfish, is confined to brackish and coastal waters. Furthermore, groundwater quality should be protected under the guidelines of directive L20 [14] which requires member states to prevent black list substances, and to limit grey list substances from entering groundwater so as to avoid pollution.

In the cases of the freshwater fish and the shellfish directives member states are required to make their own designations of waters requiring protection and to fix values of listed chemical parameters which must not be exceeded. In setting these values for freshwater fishes the member state should consider not only the quality requirements of each fish at each stage of its life cycle but also the quality of water needed to sustain all such other aquatic organisms that provide them with "shelter or food". The latter term is so broadly defined that it will include almost all living components of the aquatic ecosystem.

Under the terms of directives L222 and L281 member states are therefore required to establish programmes for the reduction of pollution to meet their stated objectives. Frequency and methodology of sampling water quality and a timetable for achieving the objectives are given in each case.

These directives should therefore be central to the concept of biology within the ARH's. The ARH's should be concerned with ensuring that the objectives of the directives, as interpreted by the Portugese government, have been met, not only in terms of the measured chemical parameters but also that these have achieved the end of supporting the desired aquatic communities in the waters concerned. The ARH's will bear the responsibility for designating the purposes to which surface waters should be put and should be careful to include provision to protect the interests of recreational and commercial fisheries [including shellfish fisheries] and to maintain the natural diversity of species and broader aquatic assemblages in Portugal's fresh, brackish and coastal waters.

3.2 Principles of biological data gathering and utilization

It is essential, if the concept outlined in the preceding section is to be met quickly and efficiently, that the biological work of the ARH's is always problem-related. As stated by this consultant in an earlier report [8], no work programme "should be carried out without a clearly defined objective, even if that objective is long term. [At all times] it must be possible to justify [the work undertaken] to those with wider responsibility for departmental planning". Those objectives should always be compatible with the goal of improving the quality of the aquatic environment for sustaining aquatic life. In striving to meet this goal full and effective use must be made of relevant and reliable data which already exists, from whatever source. Due acknowledgement of the source of the data will more readily facilitate exchange of information between departments, institutes and universities. The collation of existing morphometric, physicochemical and biological data on the reservoirs of the Tejo catchment now underway, to assist in the formulation of a strategy for management, is a good example of the use to which such data can be put.

An historical tendency to see the collection of data as an end in itself, rather than as a means to an end, must be vigorously avoided in the future [15]. It is therefore encouraging to note the collaborative venture between the Universidade Nova de Lisboa and government directorates in producing national data-bases on water quality and on land-use and other geographic characteristics. Furthermore, the free and ready access to these data, on a VAX-based national computer network will be of great benefit to many organisations including the ARH's.

The intention to include biological information in later versions of the data-base is welcomed. The experience of British Water Authorities, in the creation of systems for storage, retrieval and handling of biological data, may be a useful reference point in this process because they were developed with the active participation of the biologists involved in data collection and usage.

The acquisition of appropriate new data will, of course, be a central requirement of the ARH's work. It is important that the data collection process should be of a practical and applied nature and should not include a strategic research component. Strategic studies are rightly the province of universities and research institutes and the ARH's should encourage and support appropriate research programmes within these establishments [4,8]. PhD studies may be the most effective mechanism for strategic research since both the ARH and the student involved will share the same sense of purpose. The success of PhD studies in the estuarine project (POR/77/016) is noted [16,17].

In order to make best use of the data acquired, analysis and presentation of the results must be quick, clear and explicit. The purpose of the study or monitoring programme should be clearly stated, the essence of the results presented in a simple, easily assimilatable form, and the implications for management readily understood by policy makers. This process can be greatly accelerated with appropriate use of computer technology.

The use of models is becoming increasingly fashionable in aiding the decision-making process and if correctly used can be an invaluable aid. They may also be of considerable assistance in identifying gaps in the available information and indicating where further data needs collecting. The skills and enthusiasm of Professor Camara and his colleagues at the Universidade Nova de Lisboa could therefore be of great benefit to the ARH's if used effectively. However the use of models can be alluring since the presentation and apparent quality of the end product can easily mask the lesser quality of the information fed in. In extreme cases the use of inadequate data can lead to erroneous and misleading conclusions [18]. Modelling is not therefore to be seen as necessarily the best method of resolving all problems presented to the ARH's. It is important not to routinely discard simple and direct methods of problem-solving in favour of more complex alternatives.

3.3 Areas of potential biological interest to the ARH's

The structure and functioning of water management in Portugal is envisaged to contain elements of the systems of France, the Federal Republic of Germany, the United Kingdom and of Spain [4]. The ARH's most closely resemble the English and Welsh Water Authority system in that they will be responsible for preparation of management plans, the issuing of regulations and the provision of technical support [4]. It is to these areas that the biological work of the ARH's will be most closely allied. In addition the polluter-pay principle, common in general terms to the French and Spanish systems, should include biological considerations in its specific formulation for Portugal. Similarly, the German style, association of water users envisaged in the Portugese system, may require occasional technical support from the ARH's.

These areas of interest are considered separately with reference to the range of biological activities routinely undertaken by the Water Authorities of England and Wales and the River Purification Boards of Scotland. In each case the potential for incorporation of the listed activity within the remit of the ARH's will be considered against the existing or potential involvement of other government departments, research institutes or universities. It is understood that one of the first duties of biologists appointed to the PGIRH/T would be to evaluate the priorities for freshwater and estuarine studies within the organisation and it is hoped that the following will provide helpful guidelines. Any disproportionate emphasis on freshwater studies in the following passages reflects the consultant's area of expertise and competence and should not necessarily be seen as an accurate measure of the relative effort to be expended in each zone.

3.3.1 Operational problems of a biological nature

Many effluent disposal systems, particularly for organic waste, operate on a biological basis and are liable to malfunction with certain waste loadings. In other cases, biological nuisances, e.g. algae and certain dipterous insects, may occur at treatment plants.

The proposed water management structure for Portugal envisages the responsibility for water supply and treatment to lie variously with the municipal councils and associations of water users. The ARH's are unlikely to have any formal role in this area. Nonetheless it is probable that the municipalities and users will reasonably expect technical assistance or advice on the problems outlined above from the ARH's.

An alternative source of assistance may be the regional health authorities (Administraçaos Regional de Saude). Another possibility is that the municipalities and user associations can act jointly to develop their own expertise.

Development of this area of competence within the ARH's is seen as medium priority.

3.3.2 Biological surveillance and monitoring for environmental quality assessment

This area is central to the responsibilities of the biology departments of British Water Authorities as presently constituted. Knowledge of the chemical and biological quality of rivers, lakes, estuaries and groundwaters, is pivotal to the sound management of water resources and therefore to the proposed role of the ARH's. A number of different biological components of the ecosystem will be considered separately.

Bacteria

Potable water supply and foodstuffs from fresh and estuarine waters must be protected by stringent bacteriological standards. Consumers must be assured that these standards are met by a rigorous programme of monitoring of quality.

The responsibility for monitoring bacterial levels in potable water lies with the health authorities at present. No immediate need to transfer this area of responsibility to the ARH's is envisaged provided the health authorities provide an adequate level of service.

The ARH's may more reasonably be concerned with bacterial quality of surface waters designated for use for public supply. Monitoring should ensure that quality standards for total coliforms (37C), faecal coliforms, faecal streptococci and Salmonella laid down under EEC directive L194 concerning the quality of water abstracted for drinking purposes [19], should be adhered to. The capacity to test for other pathogens may also need to be developed [20].

At present this monitoring of surface waters for bacterial content is carried out by the Direçcao-Geral da Qualidade do Ambiente [DGQA]. As such it is one of a number of areas of potential overlap of responsibilities between that directorate and the proposed ARH's. It is essential that clear ambits of responsibility for each group are defined as early as possible since staffing and technical resources are not such as to allow for duplication of interest.

In the interim, until the matter is resolved, it is recommended that this function should be continued at DGQA on the understanding that those data needed for the PGIRH/T (ARH's) to fulfil their responsibilities are made readily available to them. Consultation between the groups on the structure of the sampling programme should ensure that their various objectives are well met.

Transfer of responsibility for bacterial monitoring of surface waters from DGQA, if agreed between the parties and central government, is seen as a low priority objective.

The ARH's may also be seen to have a legitimate interest in maintaining the quality of estuarine waters for shellfish. The European Community directive on water for shellfish sets maximum guide levels for bacteria in shellfish flesh and intervalvular fluid which member states are requested to regard as mandatory.

Testing for bacterial levels in shellfish is currently undertaken by the Administracaos Regional de Saude (ARS). However this is also an area of legitimate interest to the ARH's whose management functions must include the protection of commercial fin and shell fisheries. In the case of PGIRH/T the shell fisheries of the Tejo estuary are of particular interest in view of the collapse of the commercial oyster fishery earlier in the decade.

In the short-term the PGIRH/T should ensure that they are in receipt of all the information they require from the health authorities. Development of bacteriology within the ARH's is seen as a medium-term priority.

Phytoplankton

Phytoplankton are widely used to monitor the trophic status of lakes and other standing waters. This makes them a particularly important group for PGIRH/T because of the large numbers of reservoirs in the Tejo catchment. The same will hold for many of Portugal's other river basins.

Phytoplankton populations are also useful for the detection of heavy metals and other toxins in estuaries which will be of especial interest to PGIRH/T.

Historically the monitoring and scientific study of phytoplankton in Portugal has been undertaken by the Instituto Nacional de Investigaçao das Pescas (INIP). In the Tejo basin further monitoring of phytoplankton in reservoirs (and rivers) has been undertaken by the Direçcao-Geral da Qualidade do Ambiente (DGQA) and to a lesser extent by Empresa Publica de Aguas de Lisboa (EPAL). Whilst DGQA may currently be reducing their intensity of monitoring, it is thought that EPAL will be increasing their efforts.

The situation at INIP is less clear, as stated by Mackay in an earlier consultant visit to the PGIRH/T [9]. Current indications remain that INIP will be withdrawing from their phytoplankton studies in reservoirs but attempts by the consultant to meet INIP staff to discuss the matter were not successful.

In view of the fundamental importance of this group, as identified by Mackay [9], the relative roles of the PGIRH/T (ARH's), INIP, DGQA and EPAL must be resolved as a matter of some urgency.

If INIP do withdraw from this area then PGIRH/T should either develop its own expertise as a high priority or negotiate with DGQA to ensure that a mutually agreeable surveillance programme is maintained.

If INIP maintain their involvement and their studies are adequate to meet the requirements of the ARH's then the establishment of in-house expertise at the PGIRH/T becomes a matter of medium priority.

Other algae

In certain circumstances epiphytic and periphytic algae may be useful for assessing poor water quality in rivers. Similarly excessive growth of filamentous algae is indicative of high organic loading.

Rarely will these organisms provide additional information to that available by surveillance of other biological groups. An exception may be the use of periphyton to assess water quality in the sandier reaches of the freshwater Tejo.

Development of expertise, by the PGIRH/T in the routine surveillance of these groups is seen as a low priority.

Higher plants

Higher plants are not widely used to monitor environmental conditions although there are notable exceptions [21,22]. Of particular interest to the PGIRH/T may be their use to detect the presence of heavy metals [23]. In Britain higher plants are also extensively used for conservation value assessments [24,25].

At present development of expertise, by the PGIRH/T, in this area is seen as a low priority.

Zooplankton

The situation with zooplankton is similar to phytoplankton. This includes the potential usefulness of the group, the departments and institutes working on the group in Portugal and the future of their work.

The same recommendations therefore apply except that, as there is considerable overlap between the information derived from phyto- and zooplankton, development of expertise, by the PGIRH/T, the latter group can be assigned low priority.

Macro-invertebrates

In Europe this group of organisms is probably more widely used for biological surveillance and monitoring than any other. Advantages of the group are that they are usually easy to capture, straightforward and inexpensive to identify to the level needed for environmental quality assessment, are taxonomically diverse and ubiquitously distributed and that they live for a comparatively long time and yet move relatively short distances in a river. The group as a whole present a temporally integrated picture of the environmental stresses to which a water-body has been subjected.

In practice data collected on invertebrate communities is condensed into a simple-to-interpret biological index. Whilst these indices may be conceptually vulnerable they have been shown to be of great pragmatic value. Deficiences in accuracy of measurement, in comparison with chemical values, are more than compensated for by greater reproducibility with time. Macro-invertebrate sampling is therefore more cost-effective than chemical since fewer samples per annum are needed to assess site quality. Indications of poor biological quality should be followed up by chemical studies.

A manual of sampling practice and interpretation, suitable for Portugal, has been drawn up by Paulo Fontoura of the Universidade de Porto [26]. Whilst this consultant would differ with some of Fontoura's recommendations, it nonetheless presents a workable system whose acceptance by ARH's is desirable, (except his system of site coding), for national consistency.

Biological surveillance for surface water quality assessment is currently undertaken by DGQA. Until the PGIRH/T can develop its own expertise in this important area it should ensure that the on-going work of DGQA meets the requirements of both parties.

Development of in-house expertise by the PGIRH/T is seen as a medium priority.

Fish

Fish are rarely used for routine biological surveillance. An exception to this is the use of in-situ caged fish, sometimes telemetrically linked, to establish the presence of toxins or other pollutants in surface waters.

Development of expertise by the PGIRH/T is seen as a low priority even though this work is probably not undertaken by any other agency in Portugal.

3.3.3 Toxicity testing

This discipline is poorly developed in Portugal with the Hydrographic Laboratories of the Navy offering the only available facilities.

A recommendation that a toxicology department be established at the INIP laboratories [6] has not apparently been taken up.

In the French and Catalonian polluter-pay system toxicity testing, using Daphnia, is an integral part of the legislative framework. It is desirable that similar toxicity standards are adopted in the Portugese polluter-pay system since this will build in an essential element of protection to the aquatic ecosytem which would otherwise be lacking.

ARH's, or some other agencies, will therefore need to develop toxicology laboratories as a matter of urgency. However the practice of toxicity testing is currently undergoing critical review to ensure that laboratory testing on single species and single toxins adequately reflect the true responses of the wider communities in rivers receiving complex toxic loads.

Therefore, whilst the establishment of in-house expertise in toxicology, by the PGIRH/T, is now seen as a high priority [cf.8], it is recommended that the best available advice and training be sought. The consultant commends the expertise of Professor John Cairns Jr. and his colleagues at the University Center for Environmental Studies, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, U.S.A. The laboratories of the Agence Basins in France would also provide an alternative source of training in organisations involved in the practical application of the polluter-pays principle.

3.3.4 Fisheries Management

The management and protection of freshwater and estuarine fish stocks is routinely undertaken by British Water Authorities. Their role can be conveniently sub-divided into three sub-headings, stock assessment, fisheries management and fishing legislation.

Stock assessment

Included in this category are the study of distribution, quantity and quality of fish stocks and their life cycles and breeding requirements.

The few studies of fish in Portugese freshwaters have been largely carried out by INIP. However knowledge of the distribution and ecology of freshwater fish remains inadequate for management purposes. On the other hand much more is known about estuarine stocks.

As recreational fisheries develop in Portugal, especially as part of the tourist industry, then it will become increasingly important that fish stocks are well managed.

Studies of freshwater fishes similar to those undertaken in the estuary [16,17] should be strongly encouraged, preferably through the promotion of institute or university based research.

At this stage the development of in-house expertise, which would be likely to be both capital and labour-intensive, should be regarded as a long-term priority.

Stock management

Included under this head are habitat improvement, artificial breeding, stocking and transfer of fish, protection of breeding stocks and breeding grounds (including greater control of the water release policy of reservoirs) and facilitation of the free passage of fish.

It appears that these responsibilities are, or have been, shared by the Direçcao-Geral dos Pescas (DGP) and the Aquaculture Service of the Forestry Department. Future management programmes should be formulated in conjunction with ARH's who will bear overall responsibility for water resource planning within the catchment. However recruitment of PGIRH/T staff to work on practical rather than administrative aspects of this work should be regarded as low priority.

Fisheries legislation

Included here is legislation defining closed seasons for fishing, minimum takeable size, bag limits (no fish takeable per day per fisherman), permitted fishing techniques (bait types, net mesh size etc.), licensing and also the policing and enforcement of this legislation.

This work should remain the responsibility of the Direcçao-Geral dos Pescas but the ARH's should play a strong advisory role, where appropriate, to ensure that their management objectives are met.

3.3.5 Control of diseases (crustaceans, shellfish and fish)

Although included in this section for comprehensiveness this task is not undertaken by British Water Authorities but by the Ministry of Agriculture, Fisheries and Food.

Again three sub-categories can be identified.

i) Identification and treatment of disease.
ii) Control of the spread of disease through the control of movements of stocks within Portugal.
iii) Licensing of commercial aquaculture and import/expert controls.

The first sub-category is and should remain the responsibility of the Administraçao Regional de Saude. The others are probably the responsibility of the Direcçao-Geral dos Pescas and should remain so.

The ARH's may occasionally be required to act in an advisory capacity where there are water resource management implications.

3.3.6 Conservation and Environmental Protection

The ARH's will have the firm role of designating surface waters as appropriate to the various categories of usage defined by directives of the Council of Europe [12,13,19]. In the biological context this includes designating waters as appropriate for maintaining the quality of freshwater fisheries, (and associated aquatic organisms), and for the quality of brackish and coastal waters for shellfish.

This is an essential duty of ARH's and should be seen as a high priority by the PGIRH/T. They should also be prepared to advise central government on designated acceptable levels of individual determinands required to meet the various designated uses, as appropriate for Portugal. Furthermore ARH's should advise central government on the legislation required to make feasible the achievement of designated standards.

Outwith the terms of the above-mentioned directives some assemblages of aquatic organisms or individual taxa may require special conservation measures or areas to protect their status. Such activities are the rightful responsibility of the Serviço Nacional de Parques, Reservas e Conservacçao da Natureza (SNPRCN). Again however the ARH's should be prepared to act in an advisory capacity, and should also seek the advice of SNPRCN to build adequate conservation safeguards into the overall basin management policy.

Much more needs to be known about the distribution and status (common, rare, notable, endangered) of a wide taxonomic range of aquatic organisms in Portugal but this should not be the responsibility of ARH's.

3.3.7 Environmental Management

The ARH's have a clear responsibility to ensure that biological criteria are given due consideration in formulating water resource management proposals. Areas of interest will include planned agricultural, industrial and urban development in catchments, effluent disposal strategies (in conjunction with municipalities and users association), reservoir construction and release policy, abstraction of surface and groundwaters and provision of recreational fisheries and water-sport facilities.

This essential role will necessitate the development of in-house biological expertise by the PGIRH/T as a matter of high priority. The biologist involved need not be exclusively used for this purpose but should be deployed in other areas of interest.

Effective planning will sometimes require environmental impact assessments to be carried out. These might be best done by contracted consultants as and when required, or through the promotion of institute or university-based strategic research. Work of this kind appears to be undertaken by Paulo Fontoura of the Universidade do Porto.

3.3.8 Investigation of pollution incidents

The responsive investigation of one-off pollution incidents, termed "fire-fighting" activities, occupies a large proportion of the work-load of British water authorities. Often the investigations lead to prosecution and the need for court appearances by staff to present biological evidence. Commonly advice on remedial action to ameliorate the worst effects of the pollution is required.

The ARH's must be expected to share the same responsibilities. These may be formalised within the concept of the polluter-pays principle. The only alternative to ARH's undertaking this work would appear to be DGQA.

The priority for in-house expertise to pursue one-off incidents is dependant on the commitment of central government to provide legislation to prosecute offenders with effective deterrent force. Inadequate legislation will render the investigation of such incidents pointless.

Given adequate legislative support this area will become one of high priority for the PGIRH/T and for the subsequent ARH's. The appointed biologist(s) will need generalist expertise in phytoplankton, macro-invertebrate and fish identification.

3.3.9 Interaction with the public

ARH's will inevitably become a focus for public enquiries about environmental issues in surface and groundwaters. The capacity to deal with these enquiries, either directly or by re-direction to other agencies, will be necessary but should not require the appointment of specific members of the biological staff.

The responsibility for public education on environmental matters rests with the Instituto Nacional do Ambiente.

3.3.10 Dissemination of results

Wherever possible the PGIRH/T and the ARH's should freely disseminate their data through computer networks, reports or scientific publications. The confidentiality of sensitive data may need to be respected if this promotes amelioration of effluent standards by industry or other users but should not be seen as an unconditional safeguard against disclosure or prosecution.

3.3.11 ARH promoted research

The ARH's will not be research organisations and PGIRH/T should not therefore engage in any research activities. However so little is known about the ecological requirements of the organisms that live in the Tejo catchment that the effective use of biological monitoring data is hindered. Therefore the PGIRH/T, and the subsequent ARH's, should make every effort to encourage appropriate strategic research in the universities and research institutes.

The recommendations for further research made by a previous consultant, David Mackay [9] are endorsed here, namely

1) Fundamental studies on the distribution and autecology of the freshwater fishes of the Tejo catchment with particular reference to the effect of present and proposed reservoirs on fish stocks and their breeding requirements. Unless and until this basic information is acquired, and some concept of future recreational and/or commercial fisheries demand is established, it will be extremely difficult to effectively manage fish populations.

2) Studies on the internal and external processes, including catchment land-use, governing the productivity and trophic status of reservoirs in order to provide for their "effective and economic management" [9].

Until recently areas 1) and 2) have been most appropriate to scientists at INIP, and would still seem best placed there if the Institute continues its research interest in these subjects. The modeling skills of Professor Camara and his colleagues at the Universidade Nova de Lisboa would be a helpful aid in the reservoir study.

Other potential areas of research interest to the PGIRH/T have been identified as follows:

3) The environmental range and tolerances of selected benthic macro-invertebrates. Knowledge of the natural distribution and ecological requirements of taxa such as Ephemeroptera, Plecoptera and Trichoptera will facilitate a clearer understanding of the "environmental quality" significance of their absence from sites in the Tejo catchment.

[Studies in the United Kingdom by the consultant and his colleague have emphasised the importance of comparing the observed fauna of sites with their intrinsic potential in the absence of environmental stress [27,28].]

Alternatively it may be seen as more appropriate to study the effects of a selected chemical determinand (e.g. chromium) on the structure of macro-invertebrate and other biological communities in running-waters, in attempting to evaluate the environmental impact of tanneries or other industries or agricultural practices.

4) The role of aquatic macrophytes as bio-accumulators of heavy metals and other toxins and its significance for environmental quality assessment.

5) The influence of chemical water quality and fluctuating water levels on periphytic algal populations in sandy reaches of the River Tejo and the possible use of such populations for determining the environmental quality of the river.

[The unstable substratum and fluctuating flow regimes, due to reservoir release policies, combine to greatly reduce the diversity of macro-invertebrates, macrophytes, epiphyton and, possibly, fish and hence reduce their usefulness for biological surveillance.]

6) The competitive interaction of the Portugese oyster Crassostrea angulata and the edible oyster Ostrea edulis in the Tejo estuary and factors influencing their relative growth and mortality rates.

[The oyster industry has been of considerable commercial interest in recent years, until the devastating population crash of the early 1980's. It is important to understand the biotic and abiotic factors limiting the success of this industry.]

7) The trophic pathways and bioaccumulation of mercury and other heavy metals (cadmium, lead, zinc etc.) in the aquatic communities of the Tejo estuary and their importance in assessing the environmental impact of the estuarine industries.

In addition the PGIRH/T should look to encourage the formulation of appropriate techniques for environmental impact assessment, such as those being developed by Professor Camara's department, by providing suitable case studies. The ARH's should also consider the benefit of contracting outside consultancies, or university or institute scientists, such as Drª Fontoura, Universidade do Porto, to undertake relevant environmental impact assessments, where this is more cost-effective than in-house studies.

3.3.12 Laboratory facilities for biology

Currently the PGIRH/T has access to laboratory facilities at Alges, on the western side of Lisbon. These laboratories are being developed for analytical purposes and to meet the need for biological studies. Approximately half the space potentially available for laboratories has already been designed and is partially operational. It contains two small rooms earmarked for biological activities. An equivalent area is vacant and is available for further development for analytical or other purposes. The consultant was asked to advise on developing the biological facilities at the site.

Two general considerations are of over-riding importance, firstly the suitability of the current laboratory for the general purposes of a "water authority" and secondly the biological priorities of the PGIRH/T and the subsequent Tejo ARH.

In an earlier report O'Kane described the present facilities as "small but adequate for special campaigns" [4]. In particular the present consultant sees the laboratory as most suitably equipped for heavy metal studies and should be useful for estuarine studies. However it is clearly inadequate for any extensive programme of routine chemical analyses of the type undertaken by British water authorities and forming the basis of the RENQA programme. Although this type of analysis has previously been undertaken by DGQA it seems very possible that it will become the responsibility of the ARH's. It therefore seems regrettable that the Alges laboratory was not more clearly designed with this possibility in mind, emphasising the importance of a clear understanding of the potential purposes of a laboratory during its planning stage.

In addition to the small area made available for routine "sanitary" analyses other difficulties may arise in the sample reception area which not only appears congested but also serves as the main exit from the laboratories and offices. The two small rooms allocated to biology in this half of the laboratory abut the reception area and in the view of the consultant would be better used to improve the capacity of the laboratory for receiving and processing water samples. It seems particularly ill-advised to attempt to use this small area to provide for the many potential options for biological study which are the focus of this report and which are therefore still only at the discussion stage.

The adjacent equivalent-sized, but empty, room available to the PGIRH/T in the same building provides much more flexibility for development. Even so the development should not be hasty and should only follow very careful consideration of the various options for its use, which must include better facilities for routine chemical analyses.

A leading option for biological usage, as emphasised earlier, must be the development of suitable toxicological facilities. A prime factor is that these would not duplicate existing facilities in other organisations. This is not necessarily the case with bacteriology or with algal, macro-invertebrate, or fish-orientated laboratories which are presently catered for by DGQA and INIP. Even so it is important to establish, in advance, a clear concept of the value of a toxicology unit, the purpose to which it will be put and the work-load required of it. It would also be unwise to establish such an expensive facility if it seems probable that it will shortly be moved to an alternative site.

The consultant therefore urges extreme caution in developing any biological facilities at Alges until it is clearly shown that they are adequate to meet a well-defined need and are likely to remain in use at that site well into the foreseeable future.

Whatever the future of the Alges laboratory it is not well sited to deal with all routine analyses since the journey time from many parts of the Portugese Tejo catchment is far greater than the acceptable storage time for several chemical parameters. Regional laboratories are therefore likely to become essential, possibly at one or more of Abrantes, the Castelo Branco region and the Upper Sorraia catchment.

4. Recommendations

The new proposals for water resource management in Portugal offer a bright vision for the future. Much still needs to be done however to transform these radical ideas into a practical working system. This is as true for biology as for any other discipline.

The main purpose of this report has been to review the various activities which a biological section of a new ARH should consider developing. All the areas considered are of importance in the sound management of the country's biological resources and the suggested order of priorities for developing expertise and facilities within the PGIRH/T is based on two main considerations. The first of these is the need to incorporate biological criteria into the ground-rules for polluter-pay assessments. The second important factor is the extent to which the activities are already undertaken by other government departments and institutions. It is essential that there is no duplication of effort, particularly whilst the difficulties in recruitment to the public service persists.

Therefore, as a matter of priority, the divisions of responsibility between the ARH's and other organisations should be clearly defined. This is especially relevant to the respective roles of the ARH's and the DGQA where there is the greatest potential for overlap.

Ultimately many of the surface and groundwater monitoring and surveillance activities currently carried out by DGQA would be better transferred from that general directorate to the ARH's. This will provide much greater continuity between the planning and execution of field sampling programmes and the analyses and the application of the results. In such a way the sense of purpose in a particular monitoring programme can be maintained.

If this transfer of responsibilities to the ARH's is effected then DGQA could assume an executive role of co-ordinating the activities of the ARH's and ensuring that national policies and legislation are effectively implemented.

Until these issues have been resolved the expertise and facilities existing within DGQA should, wherever possible, be harnessed to assist the ARH's to meet their objectives. This could either be achieved by co-ordinated planning of monitoring programmes by the departments involved or by a system of contracting out of ARH activities to DGQA. The same provisions may also apply, to a lesser extent, to other departments such as DGP, SNPRCN, ARS's.

The position of INIP also needs to be clarified and the PGIRH/T should ensure effective lines of communication with this Institute are maintained since their present research programmes are complementary to the needs of the project. In particular the importance, to the PGIRH/T, of INIP's research programme on freshwater fisheries and plankton should be emphasised. The use of INIP-supervised Ph.D. studies may help to meet this objective.

In view of the fore-going considerations, highest priority has been given to the development of a well-staffed and provisioned toxicology unit within the PGIRH/T. This will meet the need for biological standards in the polluter-pay framework and will avoid substantial overlap with the work of other organisations. The undeveloped laboratory space at Alges would be suitable for this purpose but only if there is no obvious prospect of the unit being relocated in the next few years.

In order to facilitate the development of toxicological expertise it is recommended that WHO should support study fellowships in this discipline. Suggestions for host organisations are made (section 3.3.3). The other principal recommendations of this report are given in Annex 3.

In addition to specialist toxicologists it is also important that a generalist biologist is recruited to the PGIRH/T to provide a biological input into planning and management issues. It is understood that this matter is in hand and that the initial task of that appointee will be to affirm the priorities for biology within the project. It is hoped that this report will be of assistance in this task.

5. Acknowledgements

The enthusiastic support given to the consultant during his stay by the members of the PGIRH/T is gladly acknowledged. In particular he wishes to thank Margarida Cardoso da Silva, Vera Bruto da Costa and Maria Felisbina Lopes Quadrado for the time and help they so freely gave.

He is also much indebted to Professor Antonio Camara and his colleagues at the Universidade Nova de Lisboa for discussing their work with him.

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ANNEX 1

Programme of Mission

27th Sept.		Travel to Lisbon
28th Sept.	a.m.	Discussions with Margarida Cardoso da Silva and Robin Clarke on the background and objectives of the project and the purposes of the consultants' visits.
	p.m.	Discussion with Joao Carlos Crespo de Carvalho on data storage and retrieval. Background reading.
29th Sept.	a.m.	Discussion with Maria Felisbina Lopes Quadrado on collation of biological data for reservoir management planning, and on the future role of biology in the proposed Administraçoes de Regiao Hidrográfica.
	p.m.	Visit to the project laboratory at Alges and to the library of the Instituto Nacional de Investigaçao das Pescas.
30th Sept.	a.m.	Discussions with Vera Bruto da Costa on laboratory planning and management.
	p.m.	Background reading. Discussions with Margarida Cardoso da Silva on the role of biology in the proposed Administraçoes de Regiao Hidrografica.
1st Oct.	a.m.	Reading the manual on biological monitoring of surface waters by Antonio Paulo Fontoura of the Universidade de Porto. Brief discussion with Maria Helena Lima Santos and José Antonio Roxo Pires on the biological condition of the Rio Alviela.
2nd Oct.		Field visit to Abrantes with Vera Bruto da Costa and Maria Felisbina Lopes Quadrado to discuss laboratory management followed by a visit to the dam at Castelo do Bode.
3rd Oct.		River trip on the Tejo from Lisboa to Vila Franca de Xira. Discussions with staff of the Secçao de Biologia of the Direcçao-Geral da Qualidade do Ambiente.
4th Oct.		Free.
5th Oct.		Report writing [National holiday].
6th Oct.	a.m.	Report writing.
	p.m.	Discussions with Vera Bruto da Costa on laboratory planning and management and general aspects of the Tejo project.

7th Oct.	a.m.	Visit to the Universidade Nova de Lisboa for discussions with Antonio Camara and members of the group of environmental systems analysts on the development and use of models with particular relevance to the Tejo project.
	p.m.	Discussions with Margarida Cardoso da Silva on the role of biology in the proposed Administraçoes de Regiao Hidrografica.
8th Oct.	a.m.	Report writing. Discussions with Rui Moreira Roda, Angelo Magno Pinto, Margarida Cardoso da Silva, Robin Clarke and Antonio Camara on the design of a practical polluter-pay legislative structure.
	p.m.	Report writing.
9th Oct.		Report writing.

ANNEX 2

List of principal persons met

MINISTERIO DO PLANO E DA ADMINISTRAÇAO DO TERRITORIO
(Ministry of Planning and Territorial Management)

SECRETARIA DE ESTADO DO AMBIENTE E RECURSOS NATURAIS
(Secretariat of State for the Environment and Natural Resources)

Engº. José Macário Correia	Secretary of State for the Environment and Natural Resources

Direçcao-Geral dos Recursos Naturais
(General Directorate of Natural Resources)

Prof. Engº. Nunes Correia	General Director of Natural Resources
Drº. Rui Moreira Roda	Economist
Sr. Angelo Magno Pinto	Marketing Specialist

Projecto de Gestao Integrada dos Recursos Hidricos/Tejo
(Integrated Management Project for Water Resources in the River Tejo)

Engª. Maria Margarida Cardoso da Silva	Project director
Engª. Vera Bruto da Costa	Co-ordinator of analytical work
Engª. Maria Felisbina Lopes Quadrado	Environmental engineer
Sr. Joao Carlos Crespo de Carvalho	Computing services
Engº. José António Roxo Pires	Chemical engineer
Engª. Maria Helena Lima Santos	Chemical engineer
Engª. Maria Gabriela Lisboa Santos	Chemical engineer
Engº. Jorge Manuel dos Santos Castanheiro	Civil engineer
Drº. Joachim Capucho	Hydrogeologist
Srª. Maria Hortense Figueiredo	Chemical technician

Direçcao-Geral da Qualidade do Ambiente
(General directorate of Environmental Quality)

Drª. Maria Fatima Aboim de Brito	Biologist
Drº. Jorge Nascimento Fernandes	Biologist
Drª. Maria Isabel Andrade	Biologist
Drª. Maria Eduarda Texugo de Sousa	Biologist

UNIVERSIDADE NOVA DE LISBOA
(New University of Lisbon)

Prof. Dr. Antonio Camara	Civil engineer
Engª. Paula Antunes	Environmental engineer
Engº. David Pereira	Civil engineer
Engª. Ana Nunes Amaro	Environmental engineer
Engº. Paulo Pimento de Castro	Environmental engineer

OTHER WORLD HEALTH ORGANISATION CONSULTANTS

Dr. Robin Clarke (Freshwater Biological Association, U.K.)	Water quality network design

ANNEX 3

Summary of conclusions and recommendations

Water quality management and pollution control in the River Tejo and its estuary

Index: WATER POLLUTION
WATER RESOURCES DEVELOPMENT Portugal-Furse-September/October 1987

Conclusions: The new proposals for water resource management in Portugal should provide an opportunity for more extensive and effective use of biological data. Therefore the various objectives of the proposed Administraçaos de Regiao Hidrographica should include ensuring that the quality and quantity of water needed to sustain aquatic life is maintained. This requirement is outlined in Council of Europe directives. Consequently biological criteria should be incorporated in the framework of the polluter-pay principle. In the short-term this objective is best met by developing toxicological facilities. Biologists should be appointed to meet this need and also the generalist functions of the ARH's. Expertise in biological surveillance and monitoring and fisheries studies should be developed in the longer-term but these needs could currently be met by other departments, institutions or universities. Effective channels of liaison should be developed between the Projecto de Gestao Integrado dos Recursos Hidricos de Bacia Hidrografica do Rio Tejo and other organisations to ensure that their resources are best harnessed to further local and national interests. Laboratory facilities should be developed to meet these objectives, but only following careful evaluation of the purposes for which the work will be undertaken, the work-load involved and the permanency of the installations.

Recommendation	**Action by**	**Comments**
A clear order of priorities for biological studies should be developed which should be of an applied and not strategic nature.	PGIRH/T	See the consultant's more detailed recommendations in the main text.
An effective system of communication should be established to discuss the areas of responsibility for biological study of surface and groundwaters.	PGIRH/T, DGQA, DGP, SNPRCN, ARS's, INIP, EPAL, Navy, Universities, Municipalities and Associations of Water Users. Central Government.	Essential to avoid duplication of effort.
A generalist biologist should be appointed to PGIRH/T to evaluate and meet the priorities for biological studies and to provide a biological input into enviromental management issues.	PGIRH/T	In hand.

Recommendation	Action by	Comments
Standing waters should be designated for particular purposes according to the terms of the Council of Europe directives.	PGIRH/T	Including waters designated to support freshwater fishes and brackish and coastal shellfish.
The designated biological standards for parameters included in European directives on surface and groundwaters should be monitored.	Government departments (especially DGQA, and PGIRH/T)	Appropriate standards for Portugal to be set by national government.
Biological criteria should be incorporated in the polluter-pay principle.	PGIRH/T DGQA	Toxicological standards are favoured by many countries operating polluter-pay systems.
Toxicology facilities and staffing should be established.	PGIRH/T	A careful appreciation of the type and extent of the work to be undertaken is essential before developing laboratory facilities.
Study fellowships in toxicology should be supported.	WHO	Note consultant's recommendations for appropriate host organisations.
Appropriate strategic research should be fostered in Universities and research institutes.	PGIRH/T, Universities, INIP.	PhD studies recommended.
The laboratory facilities required by PGIRH/T and the subsequent ARH should be re-evaluated.	PGIRH/T	The Alges laboratory is unlikely to meet future needs. The equipment and fitting of laboratories should always result from a detailed understanding of the purpose to which it is likely to be put and the potential work-load. Confidence in the permanency of the laboratory should precede expensive fitting and installation of furniture and equipment. Regional laboratories will be essential.