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Sepik River Fish Stock Enhancement Project
PNG/85/001

Phase one final report and recommendations

PART I - Recommendations regarding fish stocking and alternative options

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This report was prepared during the course of the project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

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SUMMARY

In view of the length and technical nature of this report the following summary is provided. This should, however, be viewed in the context of, and qualifications presented in, the full text of the report and supplementary information as listed in part 3 of this report.

(1) Phase one of the project has evaluated the potential for fish stocking, alternative fisheries and non-fisheries options, and benefits and risks associated with stocking in the Sepik and Ramu River basin.

(2) Due to the unique geological history of the Sepik and Ramu river basin, present fish species diversity is extremely low. A large number of these species only enter freshwater temporarily and the majority are either too small or too low in abundance to be of significant use for fisheries purposes, although some are of present significance. It is clear that several potential major "niches" within the basin are not exploited by existing stocks. This results in very low fisheries yields in lowlands and fish abundances at higher altitudes are even more severely reduced; ultimately, above about 1000 m elevation negligible fish stocks exist.

(3) Within this area, which includes all areas of the catchment of the two adjoining river systems from the highlands to lowlands including seven PNG Provinces, an estimated 752,320 people live. Of these, an estimated 629,467 people inhabit higher ground (non-floodplain areas) including foothills up to the limits of inhabitation in the highlands. The predominant activity within this population is subsistence agriculture and fishing. Protein supply is limited and malnutrition generally widespread.

(5) The stocking of fish into rivers within this region for the purpose of providing self-sustaining increased supplies of protein is an obvious option for development. The purpose of stocking might vary from region to region. In lowlands it would essentially be in order to provide more productive stocks upon which a commercial fishery can more successfully develop. At higher altitudes fish stocking might be aimed primarily at increasing subsistence fish supply.

(6) This report evaluates the overall potential for stocking fish throughout the whole Sepik and Ramu River basins and discusses alternative options to fish stocking as methods of increasing fish, and other protein source, availability. It addresses the question of whether PNG should adopt a

strategy of fish stocking or not. (Part 2 of this report discusses species thought appropriate for stocking purposes and Part 3 lists extensive supportive information upon which the present, summary reports are based).

(7) Throughout these evaluations the project has adhered to an internationally agreed code of practice regarding the transfer of freshwater fish species.

(8) As part of the code of practice an independent advisory group was established in order to give PNG an independent view on the recommendations contained herein.

(9) Extensive multi-disciplinary research and evaluation has addressed such factors as present fish distributions, fish ecology, fisheries yields, water chemistry and associated factors, potential food availability for fishes, human population distributions and related socio-economic issues, general geology, climate and environment of the catchment, potential improvements achievable through stocking and environmental and conservation issues associated with the introduction of fish species.

(10) The overall conclusion is that fish stocking should proceed based upon appropriate species suitably appraised by methods outlined in this report and in-line with accepted codes of practice.

(11) The anticipated benefits of fish stocking for a large number of people in presently under-privileged areas are clear and justifiable. Appropriate fish stocking is anticipated to boost fish protein availability throughout the river basin in a cost-effective manner. It is also anticipated to improve the stocks of fish upon which a more productive commercially orientated fishery can develop in those areas where surplus stocks of fish above subsistence requirements might be produced.

(12) Various estimates of potential increases in fisheries production (yield) throughout the river basin are from the present estimated level of about 8,350 tons per year upwards to about 92,350 tons per year. However, it must be noted that actual increases might vary according to a multitude of factors. Even at modest estimates of increases in catches stocking is considered justifiable in both economic and social terms.

(13) In terms of stocking areas anticipated to have the greatest production (essentially lowlands), it should be noted that the establishment of improved stocks does not guarantee, immediately, an improved fishery. People would

still have to begin to exploit new stocks effectively for significant increases in yields in these areas to occur. It would, however, improve the resource upon which any future fisheries developments (self-arising or otherwise) are based. Certain issues in this respect need to be addressed by PNG with regard to the objectives of stocking lowlands. Stocking higher altitudes should be orientated more towards improving subsistence catches for which there is an immediate need.

(14) Initial introductions for the purposes of long-term establishment of resident populations are envisaged. Financial costs of stocking (Muir 1990) should, therefore, be viewed in terms of the potential establishment of a permanent resource.

(15) Considerable attention has been given to conservation and environmental aspects of fish stocking. The project is unable to guarantee that fish introductions will not disturb the present ecology of Sepik/Ramu freshwaters. Certain shifts in ecological balances may be inevitable. Through the studies that have been undertaken and the adoption of suitable appraisal procedures, the potential for such possible environmental changes can be greatly reduced. The evaluation of benefits and risks associated with stocking have been described in detail in this report. The project, however, believes its conclusions and recommendations are a rational way of developing the Sepik/Ramu fishery giving due regard to both assisting the fishing population within the river basin and conserving their environment. The ultimate decision on how to proceed rests with the government of Papua New Guinea.

(16) Three recommendations arise from this report. All are discussed and explained in detail within the text. They are as follows:

Recommendation 1 - that PNG proceed with a well thought out and rationally considered fish stocking strategy for the Sepik and Ramu river catchments based the code of practice as outlined in this document.

Following from a decision to accept and implement recommendation 1 the following recommendations arise:

Recommendation 2 - that PNG advise the project on matters relating to the objectives and priorities for stocking the Sepik and Ramu Rivers in order for the project to advise further on the most appropriate strategies for stocking.

Recommendation 3 - that PNG consider the export of Sepik and Ramu endemic species of fish for purposes of their preservation as species in populations maintained in aquaria and other facilities in other countries.

(17) The Advisory Group have been sent a complete copy of all parts of this report (including supplementary information). They were requested to provide comments for transfer to PNG on any aspect of this report. In addition, they were asked if they agreed with recommendation number 1 (above) and if this was based on sufficient information. Seven of the eight advisory group members agreed with recommendation number 1 based on the full text of this report and the supportive information (one member has still to reply). Additional comments relating to this present report were all favourable and complimentary in nature, no adverse criticisms were received.

(18) Part 2 of this report details fishes thought suitable for stocking should PNG decide to adopt this option for developing the fishery.

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1. INTRODUCTION

This report summarises results and recommendations arising from phase one of the Sepik River Fish Stock Enhancement Project. This phase investigated and evaluated the need for fish stocking of the Sepik and Ramu Rivers in Papua New Guinea.

Reports relating to conclusions and recommendations arising from phase one of the project are divided into three separate documents as follows:

Part I - Recommendations relating to fish stocking and alternative options (this report)

Part II - Stocking strategies and fish species suitable for stocking

Part III - Annex. Containing copies of all project technical reports and supplementary information

This phase of the project has been highly technical in nature and has resulted in numerous field project documents, scientific publications and other reports by project staff. In addition, reports and publications relevant to the project but produced by non-project staff have also been solicited.

The time schedules for project planning and management purposes do not always coincide with time requirements for full and proper technical and scientific documentation. By necessity, sections of this report are based on draft reports. These will be finalised during the course of the project.

Copies of all reports and other materials relevant to the project and mentioned in this report are provided in Part III (the Annex) of this report.

In order to reduce the length of this report it has been necessary to summarise background and supporting information. A somewhat simplified outline of some technical aspects of the project is also presented here. Those wishing more detailed information should refer to the supporting information as listed.

The present document (Part I) addresses the question of whether or not PNG should have a stocking programme for the Sepik and Ramu Rivers and outlines some alternatives to fish

stocking. This report should be viewed in relation to comments arising from the project Advisory Group (see later). Their comments are listed as an appendix to this document. It was thought that the question of whether to stock fish should be answered first. Should this option for developing the fishery be taken, then recommendations as to the types of fishes thought suitable for stocking are provided in Part II of this report.

2. TERMS OF REFERENCE

The terms of reference for the Chief Technical Adviser are as follows:

> "The Chief Technical Adviser will have overall responsibility for the coordination and execution of the project. Specifically, during Phase One (year 1-3) he will: determine the existing fish stocks in the catchment area, relationships between the fish species and potential vulnerability of native species to introductions - investigate interactions of the exotic fish already present in the catchment with native fish, especially for their competition for food resources, spawning habit and for other factors of importance in their life history - prepare a list of potentially suitable species for introduction and a strategy for thoroughly testing them under controlled conditions, and thoroughly discuss it with internal and external advisory bodies - prepare strategies for Phase Two, giving full consideration to the development alternatives which might have emerged as a result of this first phase of the project. During Phase Two (year 4-5), he will, together with short-term consultants, direct and execute activities required for - transfer of selected fish into controlled conditions, - their subsequent release into selected areas of the river system - monitor the native and introduced fish stocks. For this he will supervise the establishment of necessary facilities such as quarantine ponds, hatchery, fish cages, laboratory for screening fish for parasites and diseases, field stations for monitoring fish stocks, and to coordinate other activities such as collection and purchase of fish for transfer (fish, fry, fingerlings) feed production, induced breeding etc. In all his activities he will closely liaise with the PNG Fisheries Department and other government bodies. Jointly, with national co-ordinator, he will

submit six-monthly progress reports and other reports as specified in the project document."

This report deals only with phase one of the terms of reference, except where phase two strategies become relevant to phase one recommendations.

A more detailed outline of how the project has attempted to undertake phase one tasks was provided in the Project Inception Report (FAO 1987). Phase one was divided into fourteen sub-projects, all of which have now been completed although only draft reports are available for some. Reports on these sub-projects are summarised in the present document and copies are available in Part III of this report, the annex.

2.1 Points arising from the terms of reference

The project deals with the whole Sepik catchment, including areas of drainage from the highlands to the coast. In addition, it is now known that the Ramu River should be treated as part of the Sepik. The two systems are joined in their lower reaches and share a common fish fauna (Allen and Coates 1989). Throughout this report the Sepik River system is taken as including the entire catchment of the Ramu River system. Villages occurring within this region and the provinces it encompasses are listed by Coates and Mys (1989).

2.2 The Code of Practice

The project has been assisted during the course of its investigations by an established code of practice for the transfer of freshwater fishes. Such codes have been developed over a number of years but primarily in developed countries. The code currently recommended to be followed is that produced by the European Inland Fisheries Advisory Committee, an arm of FAO, and The International Council for the Exploration of the Sea. Recommended procedures under this code are detailed in Turner (1988).

3. DECISION MAKING PROCESSES REGARDING STOCKING THE SEPIK RIVER

Obviously, sole responsibility over PNG fisheries matters rests with the government of PNG. However, it is the task of the project to advise PNG on appropriate procedures regarding such activities. Within PNG the following authorities would presently be involved with decisions to import and introduce any species of fish:

(a) The Department of Fisheries and Marine Resources;

(b) The Department of Agriculture and Livestock; which is responsible for quarantine considerations relating to animal importations;

(c) The Department of Wildlife and Conservation; who are responsible for overseeing environmental aspects of projects and from whom a permit to import live animals would be required.

The PNG Department of Finance and Planning would also be involved should any budgetary requirements need to be appraised and met.

During the course of Phase One of the project the above departments have been regularly informed of project activities through the establishment of an internal Project Steering Committee.

The immediate task of the project is to provide each of the above bodies with information assisting them to make decisions relating to the project.

The following bodies outside of PNG are involved with the process of formulating information and recommendations regarding the project:

(a) The United Nations Development Programme which provides the bulk of the funds for the project; and,

(b) The Food and Agriculture Organisation of the United Nations, which is the executing agency of the project.

FAO provides two major inputs in this respect:

(i) the Chief Technical Adviser and other international staff working on the project. In addition to their direct activities, the project has actively involved, or corresponded with, scientists and other fisheries experts from a number of institutions; and,

(ii) by direct technical back-up from FAO Fisheries Department (Rome) either through correspondence or regular missions of technical experts to PNG.

In addition to all of the above personnel and institutions involved the project has established an independent Advisory Group.

4. THE PROJECT ADVISORY GROUP

In line with recommendations under the code of practice an independent Advisory Group has been established. The functions of this group are to provide PNG with a viewpoint independent of that of UNDP or FAO. The precise way in which this group operates will be detailed later. The group functions through correspondence with the Chief Technical Adviser.

With the concurrence of the Secretary of the Department of Fisheries and Marine Resources the Advisory Group was established in late 1987. Its present composition is listed in Table 1.

5. SUMMARY OF WORK UNDERTAKEN AND CONCLUSIONS REACHED

The following is a summary of conclusions regarding the Sepik/Ramu River fishery and its fish stocks.

5.1 Background to the problems with the Sepik/Ramu River fishery

Coates (1985) noted that fish catches from Sepik River floodplains were very low by comparison with those obtained from other rivers in other regions. Coates (1985) also noted that the previously introduced fish Oreochromis mossambicus or tilapia, known locally as "makau", accounted for about half of the present catch. Since then, common carp, Cyprinus carpio, a second non-native species, has entered the river and is beginning to contribute to the fishery. In 1983, it was postulated that one method of improving the fishery was to improve the stock upon which it is based by introducing further species of fish. In view of environmental considerations known to the people involved, the Sepik River Fish Stock Enhancement Project was established in 1986 and initiated in March 1987. A summary of the situation prior to the establishment of the project was provided by Coates (1987).

It should be noted that at the above stage, many technical aspects of the river system pertinent to an evaluation of fish introductions had not been studied. In particular, there was a great lack of information on fishes inhabiting highland streams and rivers and all areas away from Sepik floodplains and on the fisheries in these regions. Consequently, the project has directed efforts into investigating these areas in particular.

5.2 Simplified view of the fish stock problem within the catchment

A full description of all species of fish known from the Sepik catchment is given in Allen and Coates (1989) together with references to specimens from the river deposited in Museums. In addition, studies of the Ramu River system have been undertaken (Allen, Coates and Parenti, unpublished; Van Zwieten 1989a) which discovered some additional, but minor, species and the main conclusion of which was that the two regions have a very similar fish fauna.

Allen and Coates (1989) list 58 species of fish in 35 genera and 23 families, including three introduced species - carp, tilapia and the mosquito fish (Gambusia affinis). Details of the biology and habits of these fishes found in lower altitudes, chiefly the floodplain region, are summarised by Coates (1989a). Details of the biology and habits of fishes inhabiting tributary rivers and streams are provided by Van Zwieten (1989a, 1989b, 1989c, 1989d).

Fishes inhabiting freshwaters throughout the whole New Guinea region are derived almost entirely from marine families. The region, part of the Australasian landmass, has had a geological history which has restricted the entry of types of fishes which dominate inland fisheries in other regions. Within the Sepik/Ramu River, all native species are derived from what are primarily marine and estuarine families. In addition, of the 55 native species recorded, a large number are migratory in habit, only entering freshwater temporarily.

A comparison of the fishes occurring in the Sepik and Fly Rivers shows that the Fly River has approximately twice the diversity of the Sepik (Allen and Coates 1989). In addition, several species of importance to the Fly River fishery, for example the barramundi, Lates calcarifer, are absent from the Sepik. Hortle (1989) notes that fish catches from the Fly are substantially higher than those from the Sepik, also remarking on the potential for fish introductions into the Sepik. Allen and Coates (1989) and Coates (1989a) explain the difference between the Fly and Sepik fish faunas as follows:

(i) the Sepik River is geologically much younger than the Fly River;

(ii) the Sepik River presently has no delta in contrast to the extensive delta, mangrove and estuarine systems occurring in PNG's southern rivers; this in effect may have limited the entry into the river of several important groups

of Fly River fishes requiring this environment for their life-cycle;

(iii) an analysis of recent geological history of the lower Sepik has shown that until very recent times, perhaps only 5,000 years ago, what is now the Sepik lowlands or floodplain area was previously an inland sea which has only recently developed into and extensive freshwater habitat.

In effect, PNG has a poor diversity of fish species, totally different to the situation occurring in most other regions. Within PNG, or the Australasian region as a whole, the Sepik/Ramu River is particularly depauperate in fish species.

Consequences of these factors on the fish stocks and the fishery based upon them have been elaborated by Coates (1985, 1987, 1989a) and Van Zwieten (1989a, 1989d). Coates (1985) suggested that this was a major reason for low fish catches from Sepik floodplains. This has recently been endorsed by an in-depth evaluation of the biology of fish species occurring in floodplain regions. Coates (1989a) concluded that presently existing native fish species in floodplain regions are not well adapted to exploit this generally productive environment. This results in two important conclusions:

(i) in lower sections of the river the most productive environment is not being fully exploited by present fish stocks, thus explaining the present low yield; and,

(ii) this affords an explanation as to why the two introduced species, common carp, and especially tilapia, have produced such large populations. In simple terms, they have exploited a major, productive and previously under-utilised niche (Coates 1984, Ulaiwi 1989, Redding 1989).

The situation regarding Sepik hillstreams is perhaps more pronounced. Van Zwieten (1989a) has listed biomasses of fishes occurring in such areas. Fig. 1. shows an indication of the situation. Fish stocks in tributary rivers and streams are very low and there is a virtual absence of fish, besides eels, above about 800 to 1000 m elevation.

For more detailed explanations of this situation the above reports should be referred to. For present purposes fish introductions into the Sepik/Ramu Rivers is an obvious option for improving the situation.

5.3. The situation regarding types of organisms other than fish

Despite the obvious zoogeographic reasons for poor fish stocks within the river system the project has attempted to investigate other factors which may be responsible for the existing situation. Evaluating such factors has proved extremely difficult in certain areas due to a general lack of knowledge on the factors determining fish production in rivers. Other activities undertaken by the project have been aimed at investigating certain of the more obvious reasons why the Sepik/Ramu may have poor fish stocks. In addition, much of this work has been aimed at answering the questions relating to the niches that might be available for introduced fishes in the river system. A summary of the general findings is as follows:

5. 3. 1 Climate, geology, and vegetation

A summary of existing information on the climate, vegetation and geology of the Sepik and Ramu River catchments was made by Coates (1989b). Conclusions were that the climate, including temperature, rainfall and seasonality, suggests that Sepik/Ramu freshwaters are quite good and stable habitats for fishes to occupy. The terrestrial and aquatic vegetation of the catchment is very diverse by world standards and equable to river systems elsewhere. In fact, PNG freshwaters are, in general, perhaps in better ecological "condition" than in many other regions due to the presently relatively limited pollution of streams and habitat disturbance by human factors.

5. 3. 2 Aquatic invertebrates

Invertebrate food sources for fishes (e.g. insects etc.) have been studied by Dr. Dudgeon from the University of Hong Kong. Dr. Dudgeon visited PNG and spent about two months sampling Sepik/Ramu floodplains and streams to an altitude of about 3000 m above sea level. Results of this sub-project will take a considerable time to finish completely. Dudgeon (1989a, 1989b) has, however, summarised the findings. The main conclusions were that the aquatic invertebrate fauna was very diverse (in comparison with the fish fauna). Diversity and biomass of benthos (bottom dwelling animal communities) increased with altitude - the exact opposite to the situation with fishes noted by Van Zwieten (1989a). The Sepik/Ramu aquatic invertebrate fauna appears to be strongly influenced by Asian components. That is, the fauna is derived from the west of Wallace's Line and is more closely linked to the Asian continent rather than to Australasia.

Again, this is the opposite of the situation regarding the freshwater fishes.

5. 3. 3. Hydrology and water chemistry

Coates et al. (1983) studied aspects of the flood regime and nutrient levels in the water of the lower Sepik River and associated lakes and floodplain. Essentially, the results obtained were within the ranges of results for other river systems elsewhere. The Sepik River was concluded to be quite "normal" in these respects based on existing information.

Since 1988, additional and more comprehensive water sampling has been undertaken throughout the Sepik and Ramu catchment up to an altitude of 3000 m (Coates et al 1989). Preliminary results again suggest that Sepik/Ramu freshwaters are not unusual in comparison with many major rivers worldwide. There is no evidence that Sepik/Ramu waters are poor in nutrients (even if this were relevant to fish production).

5. 3. 4. Conclusions

The project is unable to study every aspect of the biology and limnology of Sepik/Ramu freshwaters. Even if it were, there is insufficient knowledge on tropical freshwaters in general to be able to determine the factors responsible for primary or secondary production. Based on the aforementioned considerations the project is unable to find any logical reason for the present fish stock situation other than the zoogeographic explanations as already outlined. In fact, all evidence suggests that Sepik/Ramu freshwaters, whether tributary streams, floodplain waters or lakes, should support relatively good fish stocks by comparison with other ecologically similar habitats in other zoogeographic regions.

6. SOCIO-ECONOMIC JUSTIFICATION FOR STOCKING

There is clearly scope on biological/ecological grounds for stocking the Sepik/Ramu river system with additional species of fish. Not least of the justifications for this would be the almost complete absence of fish above about 1000 m elevation. There is also clearly scope for stocking additional species in other areas where limited fish stocks already exist. However, other justifiable reasons for stocking any particular area must also exist. Such justification is also a requirement under the code of practice adopted.

Basically, to introduce new types fishes into the Sepik/Ramu river systems may possibly cause an ecological upset leading to problems with the conservation of existing native fish species and the preservation of existing fisheries. Such risks, no matter how unlikely, need to be taken in consideration of the likely social and economic benefits that may arise through fish stocking. Such a procedure is fundamental to a decision on whether or not to stock fish.

The reasons for stocking the Sepik River can be broadly divided into (i) improving the subsistence fishery and the diet of people, and (ii) improving the potential for a commercial fishery.

6. 1 Subsistence fisheries and improving subsistence diets

According to the PNG government figures roughly 50% of children between the age of 0 to 5 years are officially malnourished in most areas of the Sepik/Ramu and in some areas the figure is as high as 75%. A major problem is protein malnourishment. The worst areas for malnutrition are generally those more remote regions at mid to higher altitudes, that is foot hill areas to the highlands.

There are many factors involved with this situation. In some areas where populations have a reasonable cash income protein and other dietary problems tend to be lessened. There is no doubt that improvements in dietary education can be made by teaching people to make better use of the protein sources already available. Further economic development, thereby improving family cash incomes, may be expected to have a longer term impact on the diet of sections of the population. However, the project aims at attempting to improve protein availability in areas where limited economic developments are anticipated in the near future and where alternative sources of protein are presently limited. A recent review of population figures and environments surrounding villages shows that such areas are extensive and a large proportion of the people are involved (Coates and Mys 1989). 785,520 people inhabit the Sepik/Ramu catchment. Of these, 629,544 live in non-floodplain regions at altitudes higher than 100 m. Almost everybody lives near a lake, river, stream or other water body expected to be able to support increased stocks of fish. Employment within the catchment is much less than 9.0% of the available workforce (exact figures were difficult to establish). The majority of people are subsistence farmers or fishermen or have limited income from the sale of primary produce.

The justifications for introducing fish into these areas are self-evident. There are, however, alternative ways of improving protein supply. These would include improving agriculture and introducing new types of domesticated animals, such as sheep, goats, ducks etc., which is already being undertaken. The problems evaluating these options are extensive due to a lack of figures on the projected impacts of these alternative methods of protein supply. However, the following points are pertinent here:

(i) many areas are unsuitable for agriculture or greatly improved subsistence farming, particularly foothills up to an altitude of about 1300 m and Sepik/Ramu floodplains. The combined population of these two areas alone is about 450,000 people (Coates and Mys 1989);

(ii) irrespective of the above point, each of the possible alternative ways of improving protein supply also have associated environmental risks, perhaps more so than with introducing fish;

(iii) all of the aforementioned options will involve relatively high infrastructure costs and education and training programmes; they may suffer from the same socioeconomic problems that have hindered aquaculture development in PNG as outlined further by Coates (1989c).

Stocking natural water bodies with fish has the following advantages:

(i) it is cost effective. Details of costings are outlined later. In brief, for minimal costs, fish can be stocked that would be expected to form self-sustaining populations and provide a permanent protein food supply;

(ii) once established, fish stocks require minimal, if any, management and do not involve the government in high, long-term infrastructure and capital costs;

(iii) once introduced, fish would be expected to spread throughout appropriate habitats, thus spreading benefits throughout the region and to where they are really required, in the more remote regions.

The project does not anticipate that stocking fish will totally solve the protein supply problems, or protein malnourishment problems, in the Sepik/Ramu catchment. It does, however, conclude that fish stocking is a logical way of providing significant increases in protein availability to a large number of people in under-privileged areas.

Estimates of direct benefits in terms of tons of fish are outlined later.

Estimating the degree to which people will fish and utilise new fish stocks is extremely difficult to undertake. It has been argued that introduced stocks might not be utilised. In response to this argument the following points are relevant:

(i) all of the previously introduced fishes that have produced fishable populations, i.e. tilapia and carp and to a lesser extent trout, have been immediately and effectively fished by local people;

(ii) a review of past experiences with aquaculture and inland fisheries activities clearly shows a demand for fish products in all inland regions (Coates 1989c);

(iii) all villagers interviewed regarding this subject were enthusiastic at the thought of having fish placed in their various rivers, a lack of interest in fishing is not generally evident;

(iv) generally, people with sociological knowledge of the region that have been interviewed have endorsed the view that if fish were stocked the stocks would be utilised, although some may question whether motivational and economic factors exist in relation to the development of commercial fisheries (see later);

(v) it is evident from experiences with trout stocking in PNG highlands that stocks are often actively fished to the extent of depletion (Coates 1989d);

(vi) limited socio-economic studies on subsistence fisheries at higher altitudes undertaken by Mys and Van Zwieten (1989) indicate that, in all areas surveyed, people fish. All fish occurring are, in general, consumed, including all those species occurring at higher altitudes irrespective of their size. For example, Mys and Van Zwieten (1989) note that people fish for, and eat, even the small gudgeons (Mogurnda spp) which grow to a maximum of 10g and are usually much smaller. People in several areas also reported that fish stocks were quickly overfished and they often placed "taboos" (bans) on fishing until stocks improved.

Finally, it would be hard to imagine that if villagers lived in a region with negligible fish stocks, and new fish appeared, that, on the whole, they would not catch and eat them. In fact, it has been mentioned to the project several

times that one problem with stocking will be getting villagers to leave introduced stocks alone long enough for them to establish. However, Mys and Van Zwieten (1989) note that in many areas people already have traditional approaches to fisheries management and could probably be requested not to fish introduced stocks for a reasonable period.

Fish stocking for subsistence purposes is, therefore, seen as a logical, justifiable and economic way of improving protein availability on a wide base in many presently under-privileged regions.

Regions of high priority for stocking for these purposes will be identified later. For present purposes it is sufficient to say that it is principally the non-floodplain areas that are the priority for fish stocking for subsistence purposes. Floodplain areas may already have sufficient stocks of fish for subsistence purposes since such areas contain a greater abundance of native species and stocks of both tilapia and carp. Justification for stocking of floodplain regions relates more to the consideration of artisanal and commercial fisheries.

6. 2. Commercial fisheries

Whilst fish stocking at higher altitudes would be expected to improve subsistence protein supply, it may be the case that in some areas, on a small localised scale, modest amounts of fish could be caught and sold or used for barter. However, it is the lower altitude regions, principally the floodplain and associated lakes, that would be expected to provide stocks upon which a productive commercial fishery could develop. Floodplain regions of large tropical rivers generally have productive artisanal and commercial fisheries associated with them. A summary of African floodplain fish catches is provided by Welcomme (1976) and a summary of worldwide floodplain fisheries is provided by Welcomme (1985). However, such regions have diverse and long-established freshwater fish stocks. The Sepik and Ramu floodplains are considerably different. To summarise the project findings in this respect:

(i) it has been shown that present catches from Sepik floodplains are only about 10% of that expected by comparison with Africa (Coates 1985), they are also much lower than those from the Fly River (Hortle 1989);

(ii) present Sepik/Ramu floodplain catches are dominated by the introduced tilapia which accounts for perhaps 50% of the present catch (Coates 1985, 1986) and this is the only

freshwater species of fish in PNG ever to be exploited commercially (Coates 1989c);

(iii) common carp, a second exotic to enter the river system, is now also producing significant stocks already contributing to the fishery (Coates 1984, Ulaiwi 1989) although its final contribution has yet to be estimated since the fish is still spreading and increasing its abundance;

(iv) studies have shown that native Sepik/Ramu fishes are not well adapted to exploiting floodplain environments (Coates 1985, 1987, 1989a). This is because they are derived from marine ancestors and are, in general, main river channel dwellers avoiding the floodplain because of its instability and the unpredictable nature of the habitat. In addition, the present Sepik/Ramu floodplains are perhaps less than 5,000 years old, therefore, it is not surprising that existing native species have not colonised them to any significant degree;

(iv) in view of the above, the Sepik/Ramu floodplain fishery is already dominated by exotic species of fish which have proved very beneficial to the fishery itself.

Commercial fisheries are dependent upon two factors:

(i) productive fish stocks that will sustain a significant fisheries yield;

> There is little doubt that the stocks upon which this fishery is based could be significantly improved by fish stocking (Coates 1989a). It has been concluded (Coates 1987, 1989a) that the existing resource would severely limit fishery production if attempts were made to increase catches significantly. Not least of the reasons for this is that about 25% of the present catch of fish is composed of native fork-tailed catfishes. These fish are known to be highly vulnerable to overfishing (Coates 1987, 1988, 1989a) and could not support a productive fishery. In the long-term, greatly increased fishery production would need, presently, to be based primarily on the two introduced species, common carp and tilapia. Redding (1989) has already clearly stated that the potential to base a productive commercial fishery solely on the existing tilapia is limited; indeed there is evidence that tilapia stocks have already been over-fished, in certain areas, even at the present low levels of exploitation.

(ii) active and efficient exploitation of the resource by the fishing community;

> One problem with the consideration of present catches is the degree to which people presently fish and the increased catches that could possibly occur through increased fishing effort based on existing stocks. Despite the poor fish stock presently considered to exist, it is likely that villagers could improve upon present catches. It is also likely that the development of the Sepik/Ramu floodplain fishery is not only resource limited but also socio-economically limited (Coates 1989c). Without good infrastructures for fish processing, transportation and marketing, it will be difficult, in the short-term, to develop the fishery even if adequate stocks were to exist.

The latter problem is highly relevant to the justification for stocking floodplain regions. In short, introducing environmentally acceptable fishes might improve significantly the stocks upon which the fishery is based. It would not, however, guarantee that a productive fishery would develop because this is dependent upon socio-economic factors. The answer to this problem relates very much to government aspirations regarding the fishery. The following points are particularly relevant:

(i) the population within the area will steadily increase and, perhaps, rapidly, as health services etc. improve, as witnessed by government population growth figures (Coates and Mys 1989). The consequence of this is that, in the long-term, fishing pressure will increase and the tendency towards over-exploitation of the resource will increase with it;

(ii) it would be questionable to attempt significant fisheries development based on existing fish stocks. It generally costs significant amounts of money, and is difficult, to develop such fisheries (in any country). When one knows at the outset that the resource may limit production then the justification for such effort is equivocal. Such developments have already been attempted with the Sepik salted tilapia project which have indicated the resource and economic limitations on fisheries development in the region (Coates 1989c; Redding 1989). However, this constraint could be reduced by fish stocking thus placing the fishery on an even base with other fisheries at this level of development;

(iii) the development of the floodplain fishery cannot be viewed in isolation. It may be the case that present floodplain stocks of fish are adequate for subsistence purposes in floodplain regions; although there is already evidence of over-fishing even at present low levels of exploitation (Redding 1989). However, floodplain regions should be able to produce a surplus of fish in order to supply fish protein to surrounding areas where reduced fish stocks exist. This has already been attempted with the Sepik salted-tilapia project which showed clearly the resource limitations on this type of development in the Sepik (Redding 1989). The project concludes that increased fish availability in floodplain regions will lead to improved fish supply in areas where demand exists but stocks are more limited. Such development may take a considerable time but previous experiences suggest that this will eventually have a significant impact on protein supply and/or imported protein substitution throughout the river basin; and,

(iv) based on ecological evidence, notwithstanding the question of conservation, the project could not satisfactorily argue against appropriate fish introductions into this region. The project can see no justifiable reason why villagers living in Sepik floodplains should not have a much more productive resource, making their catches greater and reducing the effort required to catch sufficient fish. Basically, it is apparent that fish stocking would make their lives easier and, irrespective of whether vastly increased fishery production occurs in the short-term, why should this not be done ?

The project can do no more than bring to light these fundamental problems with the floodplain fishery. Decisions on how to proceed must rest with the PNG government regarding these matters. However, some degree of compromise may be possible in view of the development of a productive floodplain fishery being a long-term goal as follows:

(i) to develop floodplains slowly;

(ii) a perhaps somewhat overcautious approach to fish stocking in the shorter-term;

(iii) to introduce those species anticipated to occupy only those niches identified as being presently vacant, but expected to be the more productive ones, having the least perceived ecological impacts on existing fish stocks;

(iv) to revise stocking practices at a later stage in the light of developments as they occur. In other words, to

keep slightly ahead of the "resource" in the knowledge that additional stocks might be achieved as and when required.

> (Note, however, that this approach applies to stocking the whole catchment. But in highlands areas stocking is immediately required but may be modified in the light of ecological experience. In floodplain areas stocking is suggested to go slowly in the light of both ecological and socio-economic experience).

Such an approach is seen as logical and is why suggestions as to species suitable for stocking floodplain areas, made in Part II of this report, are even more conservative than could, in theory, be justifiably undertaken based solely on biological/ecological evidence.

7. ENVIRONMENTAL AND CONSERVATION CONSIDERATIONS

7. 1. Background

Welcomme (1988) has summarised known worldwide international introductions of inland aquatic species, mainly fishes. A total of 1,354 introductions of some 237 species into 140 countries are recorded; a number of additional, but unrecorded, introductions have also probably occurred. Of all of these, only a minority are documented to have had detrimental impacts. Unfortunately, well publicised examples of negative impacts of introductions have occurred. Against this background, there are certainly numerous examples of the great benefits arising from fish species transfers. In PNG itself, the example of the tilapia introduction into the Sepik could be taken as a positive impact, but many more have occurred world-wide. It is fundamentally because of these two opposing experiences that a code of practice regarding fish species transfers was developed, and has been adopted by this project.

Of the 1,345 introductions listed by Welcomme, very few, and certainly none in a developing country situation, have been subject to as much fore-thought, planning and adherence to a code of practice as presently exists with this project.

It is impossible to predict with absolute certainty the impact of any introduced fish into the Sepik/Ramu River systems (neither is it possible to do this with any organism introduced anywhere). The code of practice, however, is designed to minimise risks and to provide a system whereby possible risks are appraised in the light of predicted benefits. Therefore, potential negative impacts of fish stocking in the Sepik/Ramu have to be given due attention.

Environmental considerations under the Sepik project relate to the possible negative impact of introduced fishes on the existing fish species and the stocks of these upon which the present fishery is based.

7.2 Possible adverse effects on existing fish species

This section relates to conservation considerations of existing fish species as such. The project makes no attempt to discuss the reasons why these species should be conserved, which might be a separate debate in itself, but merely outlines the situation in this respect.

An up to date list of all known fish species occurring in the Sepik catchment is provided by Allen and Coates (1989). A great number of these were collected and identified during project-related activities. The Ramu River system has a very similar fish fauna to that of the Sepik but also includes perhaps one or two additional endemic (= occurring only in that place) species. Further sampling and taxonomic study may reveal a limited number of additional species and these will be included in future project deliberations when possible.

Of the 55 native species occurring in the Sepik, about 30 are distributed throughout other regions, most of them quite widely. These are primarily the migratory species such as eels, sharks, trevallies, tarpon, which spend at least part of their lives in the marine environment. They, therefore, have the ability to move widely around the Indo-Pacific region. Sepik fishes spending their time totally in freshwater, however, tend to have a much more restricted distribution within the region. These are the remaining 25 species known from the Sepik. However, of these 25 species, possibly 15 (one species has an unknown distribution) are also known to occur in other river systems in New Guinea besides the Sepik or Ramu Rivers. Other systems where they occur include the Markham, Gogol and other small coastal streams in northern PNG, and particularly in the river systems in northern Irian Jaya. Allen and Coates (1989) noted the great similarity between the fish fauna of the Sepik and Mamberamo River; the latter is the large system in northern Irian Jaya. Only 10 species are known only from the Sepik and Ramu Rivers, plus possibly one more of unknown distribution and one or two additional Ramu endemics to be added to this list at a later stage. These are referred to as Sepik/Ramu endemic species. The precise situation is somewhat complicated for the following reasons:

(i) the Sepik and Ramu river systems are the only ones in northern New Guinea to be sampled intensively. Therefore, further studies elsewhere might discover that some Sepik/Ramu "endemics" may in fact be more widely distributed than presently thought;

(ii) all of the Sepik/Ramu endemics are very closely related to other more widely distributed species. On many occasions, even well informed biologists have difficulties in recognising differences between the species in question. For example, several species of native Sepik fishes, have during the course of the project, been re-named up to four times by taxonomists;

(iii) it is uncertain to what extent conservation considerations of Sepik/Ramu species should also address those species known also to have populations in northern Irian Jaya where they are already subject to exotic fish introductions; and,

(iv) none of the Sepik/Ramu endemic species support significant fisheries in the Sepik/Ramu, although several of those known also only from northern Irian Jaya do (as outlined below).

It is not necessary here to list the species as technical details of these are provided by Allen and Coates (1989) and in other reports.

Throughout the recommendations that follow regarding fishes suitable for introduction due regard to these important species is given and is required under the code of practice. One problem is that many of these Sepik/Ramu endemics are known from very few specimens, sometimes only one. Detailed information on their biology is, therefore, sometimes lacking. Fortunately, all are close relatives of better known species and the project scientists are able to infer a great deal from this about their anticipated habits.

A major point is, however, that of the Sepik fish fauna, only a very limited number (perhaps about 10) would be potentially vulnerable <u>as species</u> through fish introductions. The majority occur elsewhere already.

Further consideration of the preservation of these Sepik/Ramu endemic species is given in later discussions of stocking of appropriate fish species. It is fundamental to the project objectives that, where at all possible, due regard to their conservation is given. Anticipated impacts on all existing species will be minimised through this process. As an additional safeguard, however, it would be

possible to obtain populations of these species and export them to other countries where they may be maintained as aquarium kept specimens. This might reduce any criticism of PNG on conservation grounds. In addition, the following points are relevant:

(i) many of these species, and all of those regarded internationally as "important", are already sought after aquarium species;

(ii) collecting and exporting most of them would not be costly; and,

(iii) certainly for the more commercially desirable species, costs of collection could be re-couped from their sale to overseas distributors.

In view of the above, this activity might be undertaken economically and would be a well regarded activity. The precise species involved can be determined later. Many outstanding issues regarding the taxonomy of Sepik/Ramu fishes have yet to be resolved. The project has good contacts with experts in this field and it is not necessary, at this stage, to be specific.

7.3. Possible effects on existing fisheries

The justification for stocking the Sepik/Ramu Rivers is essentially to improve the fishery. Were the existing fishery regarded as satisfactory there would hardly be any point in stocking. Although this is self-evident, it would be incorrect to consider that the Sepik/Ramu system presently has no species of importance to fisheries. Possible negative impacts on fisheries must, therefore, be evaluated.

The existing floodplain fishery, and the fish species on which it is based, were evaluated by Coates (1989a). The conclusions regarding species of present importance are:

(i) the fishery is dominated by tilapia. Although an introduced exotic species itself, this fishery is regarded as being presently significant in Sepik/Ramu terms (Coates 1985, 1989a, Redding 1989). Effects of introduced fishes on existing tilapia stocks should, therefore, be evaluated for each species considered for introduction;

(ii) Sepik/Ramu fork-tailed catfishes (Ariidae) are regarded as being the most important group of native species in current fisheries terms. They account for about half of the catch of native species (25% of total catch) from

floodplain regions. They are also important because (a) they occur in rivers and lakes and are available all year round, thus, a valuable source of food when floodplain dwelling species are less easily caught in the flood season, and (b) they contain large amounts of fat which is highly prized by local people and thought to be a major source of fat in the dietary intake of people living in floodplain areas and near the larger rivers. However, the fork-tailed catfishes of importance to the fishery do not inhabit the floodplain which is the key area where stocking is aimed in this region. They are also large and aggressive fishes with highly protective breeding habits and, therefore, not considered to be a highly vulnerable group provided appropriate fish stocking is undertaken with due regard to these fish; and,

(iii) the only other two species of importance to the present fishery are both gudgeons. Oxyeleotris heterodon, grows large and is the only significant fish eating predator in the river and feeds extensively on the smaller one, Ophieleotris aporos which is less important to the fishery directly (Coates 1989a).

Fish species inhabiting tributary streams at higher altitudes, that is non-floodplain areas, have been reported on by Van Zwieten (1989a, 1989b, 1989c, 1989d). Above 800 to 1000 m elevation there are negligible fish stocks and no significant subsistence fishery except for eels (caught at all altitudes). At medium altitudes (400 to 1000 m) catfishes (Arius velutinus and Tandanus spp) are of importance. At lower altitudes, these catfishes together with Ophieleotris aporos and tilapia are presently important. All species of fish, wherever they occur, contribute to the subsistence fishery (Mys and Van Zwieten 1989). Rainbowfishes (Melanotaeniidae) are presently important fishes throughout their range in rivers and streams. Although small, they are numerically abundant and, collectively, contribute a high percentage of catches. For present purposes it is assumed that there are limited fisheries of importance in higher altitude regions due to low abundances of fish (Van Zwieten 1989a, 1989d) but certain species, however, are locally esteemed. Reference to the conservation of these is made in further reports dealing with species of fish suitable for stocking such regions. Effectively, any negative impacts of stocking on existing fisheries would be negligible above 1000 m and below this level a play-off between increased abundance through new stocks and any potential decreases in existing stocks becomes increasingly more relevant towards lowlands.

7. 4 Conservation advantages of fish stocking

Conservation aspects of fish stocking of the Sepik/Ramu might not be considered to be altogether negative. There are also positive implications of stocking. It is clear that populations of people living in the Sepik/Ramu will increase. As they do, fishing pressure on existing stocks would also be expected to increase. Sepik/Ramu native fishes are already known to be vulnerable to fishing pressure. Threats from overfishing will, therefore, be inevitable. The establishment of more productive and fishable stocks could, therefore, reduce the long-term threats to stocks of native species by providing an alternative resource. This would be particularly beneficial if introduced stocks were both more easily fished and fished by different methods and in different areas to native species.

This is by no means an exaggeration. For example, Sepik/Ramu native fork-tailed catfish stocks are known to be particularly vulnerable to overfishing (Coates 1988). However, the fishery tends to concentrate on tilapia stocks which are more readily available on floodplains and in lakes. However, a number of the fork-tailed catfishes occur only in the large river channels. There is little doubt that if tilapia were not available, in order to maintain catches at present levels, the fishery would have to attempt to greatly increase catches of catfishes, thus placing stocks under considerable threat. Without an alternative stock, fishermen would be forced to seek species under more and more pressure. Presently, tilapia are fished in order to obtain the bulk of the catch, but the traditionally esteemed native catfishes can still be readily caught when required. Such an approach can also be applied to the other native species. Van Zwieten (1989d and personal communication) has already noted overfishing of certain stocks of fishes in more densely populated areas in Sepik/Ramu hillstream areas. Similarly, the development of improved fish stocks might alleviate fishing pressure on these fishes, depending on the methods used and the location of stocks.

The Sepik River system has been previously infested with the floating noxious weed Salvinia molesta. This weed had a serious impact on fishing in the region. It has, however, been very successfully controlled by the introduction of a weevil, Cyrtobagous singularis (Room and Thomas 1985). Unfortunately, the noxious water weed Eichornia crassipes, or water-hyacinth, has become established in the river and its distribution and abundance is spreading fast. It is likely that PNG will find the control of this second weed much more difficult than with Salvinia as there are no known successful biological control agents for it. Water-hyacinth

may have an impact on fishing activities in the future. The weed is expected to occupy similar habitats to Salvinia and may not cover all lowland freshwater habitats. Its occurrence, therefore, should not be taken as an argument against stocking floodplains due to a possible reduction in fishing activity via its presence. However, it is likely that water-hyacinth will force a significant number of people to shift from fishing lakes to fishing main river channels in many areas. The problem then emerges that, presently, main river channels contain insufficient stocks; tilapia and carp do not occur there. It is highly likely that water-hyacinth will promote a greatly increased fishing pressure on native catfish stocks already known to be extremely vulnerable to over-fishing. The introduction of an environmentally acceptable, productive species of fish that will occupy river channels would greatly increase the chances of preservation of native riverine stocks of fish; particularly if caught by different methods and locations to the ariid catfishes.

It is also mentioned in more detail later that fish introductions into the Sepik River may not arise solely through the Sepik project. There are a number of other possible avenues of introductions. The project, however, attempts to control introductions and restrict them to those rationally appraised and evaluated beforehand. This is regarded as a significant conservation aspect of the project in itself.

Such examples are included in order to illustrate the complexity of the problems of conservation in the Sepik/Ramu. The project considers that rational and well thought-out introductions, although still having risks associated with them, may, in fact, also have positive impacts in terms of the preservation of existing fauna and fisheries. Basically, the project considers that the key to the long-term preservation of Sepik/Ramu fish species is a rational management plan for the river basin based on sound scientific principles.

7. 5 Conclusions

It is thought possible, based on existing information, to make a sensible appraisal of those types of fishes likely to have both a positive impact on fish production and anticipated minimal impacts on existing species, as such, and any existing fisheries based upon them. Details of this procedure are provided in Part II of this report. As an additional safeguard, the exportation of those endemic species considered most vulnerable might be considered.

The dangers of introduced species are minimised in the Sepik/Ramu Rivers because of the limited extent of the existing fauna and the fishery based upon them. The areas where existing species and existing fisheries are potentially vulnerable have been pin-pointed. Provided appropriate stocking strategies make note of these factors, benefits from potential increases in fish production are anticipated to outweigh any foreseeable ecological disturbances.

The project is unable to guarantee that certain Sepik/Ramu native fishes would not be affected by stocking. It has, however, done all within its means to safeguard against this.

8. OPTIONS TO STOCKING

8. 1. Non fisheries options

Such options relate mainly to agricultural development and the development of other cash earning opportunities.

8. 1. 1 agricultural options

In terms of increasing local protein supply, agriculture is the obvious option to fish stocking. Some aspects of this subject have already been covered above and the following points are pertinent:

(i) the project is unable to obtain accurate estimates of the impact of planned agricultural developments on increased protein supply in rural areas of the Sepik/Ramu;

(ii) each agricultural option has environmental aspects also;

(iii) agriculture in PNG is based on exotic species and this is, therefore, on environmental grounds, a similar option to fish stocking;

(iv) fish stocking will impact remote areas where agricultural developments, which require much extension and training inputs, may be expected to take a considerable time to have an impact; and,

(v) fish stocking is cost-effective in terms of supplying modest amounts of increased protein supply to the more remote and underprivileged areas.

8. 1. 2 increased cash-earning opportunities

A basic justification for stocking fishes is to improve subsistence nutrition in under-privileged areas and provide a basis for cash-earning opportunities through fisheries activities in areas where other resource options are limited. However, should villages and households in these areas have access to other incomes, particularly if considerable in nature, then the need to fish for a living will decrease. It is hypothetically possible that in the future, cash incomes may greatly increase, for example through oil and mining royalties should these resources be discovered and exploited. Unfortunately, it is impossible to predict the future in this fashion. Consequently the project can do no more than analyse the existing situation and make predictions based on present data and likely foreseeable developments. At present, less than 9.0% of the population of the Sepik/Ramu obtain cash from wage or salary earning (Coates and Mys 1989). It is concluded that in key target areas where improvements are desirable, there are presently, and foreseably, limited options for improving village life. In large sections of the Sepik/Ramu catchments, for logistic reasons, agricultural and other developments are anticipated to proceed slowly. Fish stocking is, however, known to be one way of improving protein and fish resource availability fairly rapidly and immediately.

8. 1. 3 Conclusions

Non fisheries options should be addressed by PNG in evaluating fish stocking in the Sepik River. These alternative options should be addressed by a multisectoral approach to development. Fish stocking is perceived by the project as one way of assisting alternative methods of development which are already underway.

8. 2 Fisheries options

Notwithstanding consideration of the above multisectoral options theoretically available the following fisheries options exist:

8. 2. 1 Aquaculture

A review of aquaculture experiences in PNG has been undertaken (Coates 1989c). Conclusions were:

(i) despite over thirty years of attention to aquaculture in PNG this activity has had little impact in

terms of fish production due mainly to socio-economic constraints;

(ii) freshwater aquaculture in PNG, even if socio-economic constraints can be overcome, would probably need to be based on introduced exotic species of fish. Since these might be expected, sooner or later, to enter river systems, this is considered a parallel option to stocking fish directly into rivers;

(iii) aquaculture development will be costly in terms of infrastructure, extension and associated expenses;

(iv) the greater part of the benefits arising from aquaculture would be limited to those people who had aquaculture facilities. Therefore, benefits arising from aquaculture would not be evenly dispersed in the same sense as fish stocks in rivers would disperse;

(v) stocking fish in rivers, in view of the above, is far more cost effective in terms of improving the fish protein resource on a wide base; and,

(vi) stocks of fish, once established, would be self-sustaining and avoid the necessity for immediate infrastructure and management costs.

8. 2. 2. improved coastal fisheries and transportation of fish products inland

Coastal resources are less resource limited in PNG and could, in theory, be developed in order to supply fish to meet demand inland. The problems with this option are as follows:

(i) coastal fisheries presently suffer socio-economic constraints on their development. Their development in terms of satisfying coastal demand alone is a difficult task to achieve;

(ii) people inland may well prefer to consume freshwater fishes. In fact, in some regions, freshwater fish is moved to the coast for sale, although on a limited scale;

(iii) in the key areas where improvements in the lifestyle of people is to be achieved, such people do not have the resources with which to buy fish from the coast; and,

(iv) such an approach does not encourage people to be locally self-sufficient.

8. 2. 3. do nothing

This is a serious alternative to fish stocking and, therefore, should be mentioned. It is obvious, of course, that this option in effect means that PNG authorities are not initiating a programme under which it is known that significant benefits could arise, but with which there are associated risks. PNG might decide that the risks are too great and seek alternative avenues of development in the Sepik/Ramu. The project does not make decisions on such matters but this option is available to PNG.

However, this option in itself would not necessarily mean that new species of fish did not enter the river system. Fish introductions might occur from a number of other sources as outlined below. The Sepik project is aimed at attempting to ensure that the "correct" species enter the river after being properly evaluated.

8. 2. 4 conclusions

Options for non-fisheries ways of alleviating problems of protein supply rest with PNG authorities other than the Department of Fisheries and Marine Resources. Of the fisheries options available the only real alternative to fish stocking of the Sepik/Ramu is considered to be to leave the river system alone. However, note remarks made concerning the dangers of removing attention to fish stocking outlined below.

9. CONTROLS ON FISH INTRODUCTIONS INTO PNG - GENERAL

The activities undertaken by the project, through the adoption of a code of practice and recommended procedures for the transfer of fish species, are regarded as the rational way of dealing with the complicated problem of whether or not to stock fish and to determine which species are suitable should stocking be desired.

There are, however, some broader issues that might be addressed. Fish introductions through the Sepik River Fish Stock Enhancement Project are not the only potential source of fish introductions into PNG. Numerous institutions, businesses and private individuals have expressed an interest in attempting to bring species of fish into PNG for various purposes. Regulations presently exist in PNG regarding fish introductions. Generally, a permit is required which has tended to be declined except for the importation of trout eggs from Australia. Nevertheless, several unauthorised fish importations, known to the

Departments of Fisheries and Marine Resources and Agriculture and Livestock, have occurred. In addition, non-native fish species may enter PNG indirectly via Irian Jaya. This may occur either through people carrying them whilst moving traditionally between the two countries or fish being introduced into catchments in Irian Jaya that drain into PNG's major river systems. The latter has already happened with one species (Anabas testudineus) entering the Fly River system, via Irian Jaya, originally from Java (Coates 1989c).

The project has outlined the benefits of fish introductions but also some of the dangers, particularly if undesirable species were to enter the country or if imported fish did not undergo proper quarantine procedures. PNG may wish to consider its present legislation with a view to tightening controls on species transfers and addressing the issue of penalties associated with infringements of regulations with regard to the potential severity of damage that could arise.

The Sepik River Fish Stock Enhancement Project has, to a certain degree, acted as a control for fish importations into PNG in that it has provided a method by which proposals to introduce fish species can be rationally evaluated. In this respect, the project is regarded as essentially limiting fish introductions, to those acceptable and rationally appraised, rather than being in existence specifically to increase fish introductions.

Pressure to import aquatic species is likely to increase in the future and to come from a number of sources. It may be difficult, and sometimes undesirable, to have a blanket ban on importations. The establishment of long-term procedures will significantly increase the safeguards against any potentially unsound introductions in the future. PNG may wish to consider extending the principles underlying procedures adopted by this project more generally within PNG and in particular to adopt a code of practice regarding the transfer of any aquatic organisms for the future.

The project suggests that PNG should adopt a code of practice, similar to that outlined here, on a more wide base. In particular, the adoption of a code is thought desirable for the introduction of any aquatic organism (marine or freshwater) into any part of PNG. It should be noted that no matter what the intended use of such an organism each proposed introduction should be viewed as a potential method of entry of the organism into PNG's natural waters. PNG may also wish to consider reviewing its present legislation (and penalties) concerning importations and introductions of aquatic organisms in the light of the

serious potential detrimental effects arising from inappropriate and illegal importations and introductions.

10. QUARANTINE ASPECTS

Quarantine procedures, and safeguards against introduced diseases, are important considerations with the transfer of any living organisms. Quarantine considerations are outlined in some detail under the code of practice. These considerations will come to bear if PNG decides to stock fish into the Sepik/Ramu. As such, they are explained in Part II of this report where specific recommendations regarding the possible importation of certain species are made.

For each proposed introduction, recommended quarantine procedures will be provided by the project. These should be assessed by the Departments of Fisheries and Marine Resources and Agriculture and Livestock (the latter has statutary responsibility over this matter) in the light of any comments in this respect arising from the Advisory Group.

11. INDONESIA

A very limited part of the Sepik River system arises in Irian Jaya (Indonesia). Therefore, species of fish introduced into the Sepik have the potential of entering areas of Indonesian jurisdiction. Vice versa, fish could enter the Sepik River from areas of Indonesian jurisdiction. A large number of fish species are known to have already been introduced into Irian Jaya, either through stocking programmes, aquaculture activities or by other means. Since Indonesia has also recently given attention to the adoption of a similar code of practice to that already in operation with the Sepik River Fish Stock Enhancement Project and, PNG and Irian Jaya share a very similar native freshwater fish fauna, experiences gained in the two regions are relevant to both countries. The exchange of information between the two countries is highly desirable and would be mutually beneficial, especially regarding the biology of native New Guinea fishes, presently existing fisheries and the impacts of introduced exotic species.

In view of the above factors, the project regards this matter as an opportunity for information transfer for the mutual benefit of both countries. Since this is matter of jurisdiction between the two countries, it is suggested that this be persued by PNG authorities. However, the project

notes that facilities for such information transfer and mutual co-operation within the region exists under the FAO Indo-Pacific Fisheries Commission. This commission is composed of a number of countries within the region, Indonesia being one member. Unfortunately, PNG is not presently a member of this organisation. PNG may wish to consider becoming a member country of the IPFC which has other benefits regarding fisheries matters other than those specifically mentioned here. Further details of IPFC and its activities can be provided to PNG by FAO. The IPFC would provide a most suitable forum for discussion and co-operation, in addition to any other avenues of approach that PNG might like to take.

12. ANTICIPATED BENEFITS AND ECONOMIC COSTS OF STOCKING

It is very difficult to predict the impact of fish stocking on increased fish stocks or fish catches and utilisation. Some rough estimates can be provided for planning and budget purposes. Due to the number of factors involved these should not be taken as guaranteed benefits. Actual benefits may be more or less than the following figures suggest but these are regarded as reasonable estimates.

12. 1. Floodplain regions

Stocking of floodplains would be directed towards the development of a commercially orientated fishery. A considerable body of information exists on the fishery production from floodplain rivers throughout the world and this can be used as a basis for comparisons. Coates (1985) estimated present Sepik floodplain catches to be between 3,000 and 5,000 tons per year, averaged for present purposes to 4,000 tons per year. Similar rivers elsewhere, with adequate fish stocks, were estimated to produce about 30,000 to 45,000 tons per year, averaged to about 40,000 tons per year for present purposes. These comparisons make allowances for differences between regions in the numbers of fishermen available and the areas available for fish production to occur.

Based on the above rough approximations there is potential for a ten-fold increase in fish catches from Sepik floodplains from about 4,000 to about 40,000 tons per year. In addition, a similar scale of increase in catches could be anticipated from Ramu floodplains although these are smaller and less populated than in the Sepik. Both regions combined might have the potential to increase from about 6,000 to 60,000 tons per year. This, however, assumes that (a) the Sepik/Ramu has equivalent fish stocks, and (b) Sepik/Ramu

people fish to the same extent, as occur in other rivers used for these comparative purposes. It is the uncertainties of fishing effort that make it particularly difficult to arise at a reasonable estimate of potential increases in fishery production. As such, these figures should only be taken as indicating the relative scale of potential improvements rather than an anticipated accurate figure in tons of fish produced.

Although the above analysis suggests scope for a ten-fold increase in catches, even a 50 to 100% increase would alone be considerable. This would be equivalent to between 3,000 and 6,000 tons per year extra fishery production. Therefore, it is not necessary to become over-optimistic regarding potential improvements in order to justify stocking.

An example of the success of fish introductions exists with the tilapia stocks in the Sepik/Ramu. Tilapia now accounts for an estimated 50% of the catch from floodplains (Coates 1985). As an example, were another species introduced that would do as well as tilapia within the river, without upsetting existing stocks, then that species would provide a further 50% increase in catches, that is, 3000 tons per year. Of course, tilapia has succeeded particularly well within the river. Other species may not do as well, but, equally, other species might do better. This example, however, assumes that people would continue to increase their total catches. Such sociological considerations have been discussed above in relation to the justification for stocking floodplain regions. It could be argued that people may not increase their total catches and fish utilisation in the short-term, by, for example, fishing less because of increased returns. Fish stocking, even under this scenario, might also be regarded as a positive benefit because it effectively means people catch more with less effort. Apart from being popular with the fishing community, this would also have the benefit of increasing the amount of time villagers have available for alternative activities. Such might include, amongst other things, other food production activities, health considerations and education.

12. 2 Subsistence fisheries in non-floodplain areas

Estimates of potential increases in fish catches from tributary rivers and streams in the highlands and upper lowland regions are particularly difficult to estimate. There is a lack of data on fishery production from such rivers in other regions. Such smaller rivers and streams are known to contain much lower abundances of fish than floodplains. However, the majority of people live in these

non-floodplain regions which also comprise the great majority of the catchment. Potential increases in fish catch per person may be minor. However, when population numbers and areas are considered, benefits in terms of total fish catches from highlands and foothill regions might rival estimates for floodplain regions.

Van Zwieten (1989a) has compared actual biomasses (kg per unit area) in Sepik/Ramu streams with limited information from other regions. Results are difficult to interpret due to a lack of data suitable for comparison with the extensive Sepik/Ramu data. Sepik/Ramu foothill (i.e. less than 400 m elevation) river and stream fish biomasses are, however, perhaps, less than 50% of known biomasses in other regions worldwide. Above foothills (i.e. above 400 m), Van Zwieten notes that Sepik/Ramu fish stocks are considerably reduced and practically non-existent above 1000 m. Regions at such altitudes in other zoogeographic zones are known to support fish stocks and, in places, actual commercial fisheries. Limited information exists, however, in order to provide figures.

One method of addressing this problem is to base estimates on known population distributions and hypothetical potential catches. In Table 2 the hypothetical catch at various altitudes is based on an estimate of catches achievable there in relation to floodplain catches. Present total catch for the whole Sepik/Ramu catchment is estimated at 8,359 tons per year (Table 2). This figure agrees closely with the estimate made by Coates (1989c). Figures for present catch from non-floodplain areas also agree closely with those made by Mys and Van Zwieten (1989) based on village census data and knowledge of existing fish stocks. Estimated total potential catch is 92,338 tons per year (Table 2). Of this, an increase in total catch from 2,359 to 32,338 tons per year is estimated for non-floodplain regions. These figures, however, should be viewed with caution; they are very approximate estimates based on "guesses" for catches achievable from higher altitudes.

The above figures give an indication of the scale of potential benefits of fish stocking. They also indicate the great benefits of stocking higher altitudes for two main reasons. First, the numbers of people occurring there; although catches per person are expected to be small, total potential catch for the population is high. Second, because altitudes above 1000 m have presently negligible fish stocks, stocking such regions has a great potential impact in terms of improving upon present catches; note that in all regions, even those with negligible fish stocks, people do fish (Mys and Van Zwieten 1989).

A second way of estimating potential increases in catches is illustrated in Table 3. Here, potential increases are estimated from various estimates based on hypothetical increased catches per person throughout the catchment. Based on an increase in catch per person per year of 0.5 kg the figures illustrate that total increased catch from non-floodplain areas would be 345.2 tons per year. An increased catch of 0.5 kg per person per year is a very low indeed and considered very conservative. This figure equates to only one fish weighing 250 g every six months for each person at all altitudes above 100 m. Even at this low estimate, total increased fish catches are significant at 345 tons per year and stocking is cost-effective. Other calculations based on higher anticipated catches per person provide estimates of increased catches through stocking non-floodplain regions of between 690 and 5,731.5 tons per year (Table 3). These estimates (Table 3) are considered realistic, and very conservative at the lower end of the scale. Even based on existing stocks in such regions, present catches are estimated at between 1000 to 2100 tons per year from non-floodplain regions (Mys and Van Zwieten 1989); note, however, that in this estimate 397,968 people live above 1000 m (Coates and Mys 1989) where fish stocks are non-existent except for eels (Van Zwieten 1989a).

Such figures are used for illustrative purposes only but show that, even with a very pessimistic estimate of potential increases in catches achievable, stocking can have great overall benefits and is cost-effective.

In addition to the above estimated potential benefits, it is important to consider that non-floodplain regions are, in general, those areas where protein availability is known to be presently more limited. In short, such areas are the key areas where improvements in protein availability are most important. Benefits arising from such improvements are, therefore, perhaps more important than a consideration of tonnages of fish alone might indicate.

12. 3. Economic costs of stocking

Cost estimates vary according to which species are considered for stocking. At present, certain introductions would be relatively inexpensive, whilst others, particularly those requiring large capital inputs, would be more expensive. Costs of stocking also depend upon the extent that existing facilities can be used and the possibility of joint utilisation of any existing or proposed facilities between stocking and aquaculture practices in PNG. This particularly applies to highlands regions. In addition, the

level to which PNG wishes to quarantine imported fishes, especially colder water tolerant species, is relevant to the costs of stocking. Such considerations will be detailed in a separate report covering the various options available.

Preliminary figures show that even if only the most moderate estimates made above as to potential or immediate benefits of stocking are taken, economic costs of stocking are negligible by comparison. In addition, predicted benefits arise from self-sustaining populations of fish. The immediate costs are for initial stocking but benefits arising from this are sustained permanently through established self-replenishing fish stocks. Detailed economic appraisals of the cost-effectiveness of stocking will be provided in the forthcoming separate report.

12. 4. The possible failure of introductions

It should be noted that the project cannot guarantee that any species stocked into the Sepik/Ramu will succeed in establishing useful stocks, or in fact establish at all. Failed stockings are a potential risk to investments. However, the project obviously will recommend species with anticipated good changes of success based on available information. Should certain species fail in their purpose, they can be substituted at a later date by alternative species. The project does not anticipate that this is a serious constraint to investment considerations but it is necessary to mention these possibilities.

13. ANTICIPATED TIME TO ESTABLISH FISH STOCKS

Again, this is difficult to estimate, but a rough indication can be given in order to assist project related budget, planning and management considerations.

Each species to be introduced would first have to undergo approved quarantine procedures before stocks were available to be placed into the rivers. The time required for this depends on the species in question and, to a certain extent, on the quarantine procedures PNG decides to adopt based on project recommendations in this respect. Some species could be ready for stocking within an estimated nine to twelve months of importation, even with full quarantine procedures adopted, others considerably longer. The following refers to lengths of time anticipated to provide significant benefits after release from quarantine and stocks being available for stocking.

Fortunately, past experiences with exotic species in the Sepik give some indication of the speed of colonisation of the river system:

(i) tilapia - it is known that tilapia entered the Sepik in the early 1960's, probably from a single major introduction into the screw river from a fish pond near Maprik. By the 1970's the tilapia stocks were thought to be so widespread and abundant that plans were already afoot to base a commercial fishery on this species as early as 1972/3. However, tilapia were still spreading to upper regions of Sepik floodplains by the mid-1980's according to Mys, Van Zwieten and Ulaiwi (personal communications). These project scientists estimated that tilapia spread at about 20 km per year; and,

(ii) common carp - Ulaiwi (1989) has investigated the spread of common carp in the Sepik river system, again from a single point of entry, and estimated that this fish has spread through floodplain regions at about 40 km per year with approximately a two year delay before first entry into an area and the fish becoming a significant part of the fishery.

In some respects, the above experiences suggest rapid increases in abundance where introduced but a slow rate of spread between regions. At an average of 40 km per year (e.g. for carp) it would take a species 50 years to spread throughout Sepik floodplains (1000 km in length) from a single introduction at either end of the river. However, the equation becomes much more optimistic if multiple introductions are undertaken. If fish were introduced at 10 equally spaced locations along the region it might take only 2 to 3 years to develop significant populations throughout the whole floodplain region (note: in this example fish move 40 km every direction). The time taken to establish fully developed and ecologically balanced stocks would be longer.

There are no data for stocking highlands regions in this respect. A difficulty in stocking higher altitudes is the fact that sub-catchments are separated somewhat and fish may have difficulty moving from one sub-catchment to another. Multiple, widely dispersed stocking would again alleviate this problem. In areas stocked, significant populations might arise within one to five years depending upon the success, and life-history cycle, of the species involved.

In summary, it might be expected that in areas where fish are stocked, and those areas immediately adjacent, significant stocks might arise in perhaps two years, but

longer for slower growing fishes maturing at a greater age. The development of significant populations throughout the catchment, especially at higher elevations, would, however, take much longer. The length of time required for this would be considerably reduced by multiple stocking the same species over a wide range.

14. RECOMMENDATIONS ARISING

Recommendation 1 - that PNG proceed with a well thought out and rationally considered fish stocking strategy for the Sepik and Ramu river catchments based on the code of practice as outlined in this document.

(Recommendation 1 should be considered in the light of comments arising from the Advisory Group as listed in the annex to this document. Under the code of practice each species suggested for introduction should also be appraised in the light of comments from the Advisory Group - this activity is detailed in Part II of this report which deals with the question of which species are appropriate to stock).

Following from a decision to accept and implement recommendation 1 the following recommendations arise:

Recommendation 2 - that PNG advise the project on matters relating to the objectives and priorities for stocking the Sepik and Ramu Rivers in order for the project to advise further on the most appropriate strategies for stocking.

Recommendation 2 particularly relates to stocking options for the Sepik/Ramu floodplains and priorities perceived in terms of commercial fishery development in relation to the factors outlined in this document.

Recommendation 3 - that PNG consider the export of Sepik and Ramu endemic species of fish for purposes of their preservation as species in populations maintained in aquaria and other facilities in other countries.

With respect to recommendation 3, it is not inferred that stocking will affect these species. This is an additional safeguard. The project will advise on the species involved and determine a method by which this can be done cost-effectively, with minimal effort.

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Table 1. Composition of the project advisory group as of October, 1989.

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Table 2. Hypothetical catches achieved via fish stocking at various altitudes within the Sepik/Ramu catchment based on known catches from floodplains and catches that can be hypothetically achieved from floodplains (from Welcomme 1976). Population numbers and distributions are from Coates and Mys (1989). % Catch refers to estimated (theoretical) percentage catches achieved by comparison with present floodplain catches (except above 1000 m where presently negligible fish stocks exist). Potential catch is calculated in the same fashion based on the theoretical percentage floodplain catch assuming stocking occurs throughout the catchment.

ALTITUDE (m)	NUMBER OF PEOPLE	% CATCH	PRESENT CATCH		POTENTIAL CATCH	
			kg per person	total (tons)	kg per person	total (tons)
Floodplains	about 95,000	100	63.2	6,000	632.0	60,000
<100 excluding floodplains	60,976	25	15.8	960	158.0	9,600
101 - 500	190,948	10	6.32	1,207	63.0	12,029
501 - 1000	40,551	7.5	4.74	192	47.0	1,906
1001 - 1500	98,600	5.0	0	0	31.6	3,115
1501 - 2000	199,070	3.0	0	0	19.0	3,782
>2000	100,298	3.0	0	0	19.0	1,906
Total all areas				8,359		92,338

Table 3. Hypothetical increases in catches achievable from non-floodplain areas of the Sepik/Ramu via fish stocking based on the assumption of increased catches per person (as stated) at various altitudinal zones.

ALTITUDE (m)	NUMBER OF PEOPLE	HYOPTHETICAL INCREASED CATCH IN TONS PER YEAR BASED ON HYOPTHETICAL INCREASED CATCHES PER PERSON PER YEAR OF:						
		0.5 kg	1.0 kg	2.5 kg	5.0 kg	10.0 kg	15.0 kg	20.0 kg
<100 excluding floodplain	60,976	30.5	61.0	152.5	305.0	610.0	915.0	1,220.0
101 - 500	190,948	95.5	191.0	477.5	955.0	1,910.0	2,865.0	-
501 - 1000	40,551	20.3	40.6	101.5	203.0	406.0	-	-
1001 - 1500	98,600	49.3	98.6	246.5	493.0	-	-	-
1501 - 2000	199,070	99.5	199.0	497.5	-	-	-	-
>2000	100,298	50.1	100.2	250.5	-	-	-	-
Total all areas		345.2	690.4	1,726.0	2,704*	4,167*	5,427*	5,731.5*

- = such catches per person assumed unrealistic at that altitudinal zone

* totals for these columns are based on totals in the columns plus the highest catches for other altitudinal zones where catch estimates occur.

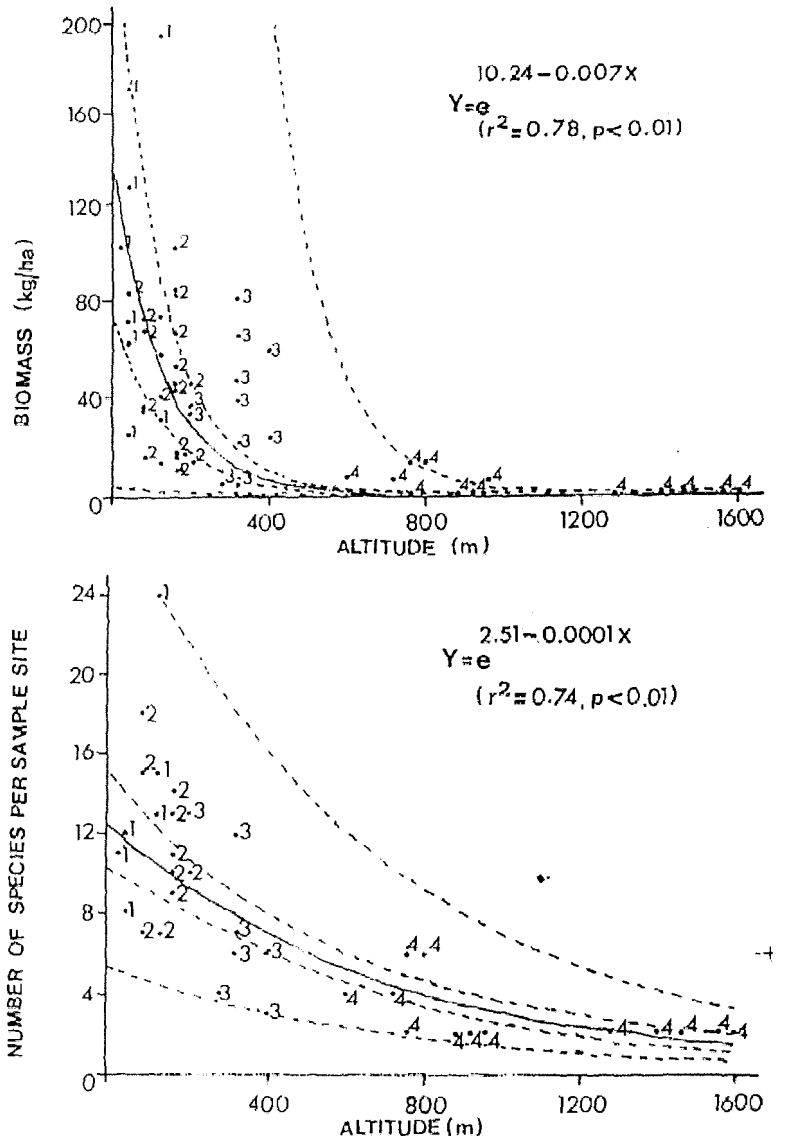

Fig. 1 The relationship between fish biomass and number of species and altitude in Sepik/Ramu lower-order streams (from Van Zwieten 1989a).

ANNEX

OPINIONS ON THE RECOMMENDATIONS ARISING FROM THE ADVISORY GROUP

The project advisory group has been sent a complete set of project reports as listed in the project phase one recommendations and conclusions (parts 1, 2 and 3). In addition, most of the advisory group members have been familiarised with project activities over a long period of time. Each member of the group functions independently and was asked to provide his own personal view, not that of his organisation or country (the exception is Dr. Pullin who personally indicated he could only present the view of I.C.L.A.R.M.). The project Chief Technical Adviser has corresponded frequently with the group in order to answer queries and provide additional information when requested.

Group members were asked to complete an "opinionaire" in order to quantify their responses if necessary. In addition to this opinionaire, group members were requested to provide additional comments and elaborate on their views if appropriate. All group members were informed that should they see a need to relay opinions to PNG authorities concerning matters they thought important, that had not been raised in project reports, they could do so through project channels. All such communications will be presented to PNG authorities without edits.

Only one of the recommendations arising from this report needs to be specifically addressed by the advisory group although they were free to comment on any aspect of the report. This is recommendation number 1 (the only one in this report dealing directly with fish introductions). Advisory group members were asked to provide advice relating to this recommendation as listed overleaf:

Copy of contents of opinionaire sent to the Advisory Group in relation to recommendation number 3 of part one of the phase one report of the Sepik River Fish Stock Enhancement Project

Dear Advisory Group member,

Recommendation 1 of part one of the phase one report reads:

" - that PNG proceed with a well thought out and rationally considered fish stocking strategy for the Sepik and Ramu river catchments based on the code of practice as outlined in this document".

Note that this recommendation relates to the question of whether or not PNG should proceed with a stocking programme for the Sepik/Ramu Rivers, that is, implement phase two of the project. Whilst not addressing the issues associated with stocking directly, the project feels it is pertinent to address this question first of all.

For clarification of this recommendation please note the following points are inherent in this recommendation and are to be assumed will arise after decisions relating to this recommendation are made by PNG authorities:

- all species proposed for introduction will be subject to the code of practice and further details on each species will be presented to the advisory group for their further deliberations in terms of:

(a) suitability of their introduction,
(b) the need for their introduction in both ecological and socio-economic terms,
(c) analyses of their potential benefits and risks,
(d) quarantine considerations relevant to their introduction,
(e) conservation and environmental considerations, and
(f) any other factors as outlined by the code of practice or raised by project staff, PNG authorities or Advisory Group members.

In relation to this recommendation and in the light of information provided to you in part one of the project phase one report (and supplementary information) could you please circle your opinion on the following opinionaire:

SUMMARY OF RESPONSES ARISING FROM THE ADVISORY GROUP

Copies of responses to this opinionaire are appended to this document. A summary of the responses from the Advisory Group is provided here.

(Note: for present purposes written responses from Dr. I. Payne and Mr. Pholprasith have not yet been received. The project CTA has, however, discussed these matters at length with Dr. Payne by 'phone and his verbal views are incorporated accordingly).

Question 1 ("is the information on which this recommendation based adequate to justify the recommendation ?").

Responses: "YES" - 5
"PROBABLY" - 2
Other options - 0

No negative responses were received (i.e. "NO" or "UNLIKELY")

Question 2 ("do you agree with the recommendation ?")

Responses: "YES" - 7
"PROBABLY" - 0
Other options - 0

No negative responses were received (i.e. "NO" or "UNLIKELY")

Additional comments received:

Comments relating to this specific section of the report were received from a number of Advisory Group members. All of these, however, were supportive and complimentary towards the evaluations that the project has undertaken (other comments referred to matters relating to part 2 of this report).

Conclusions on Advisory Group responses

It is obvious that this section of the phase one report (discussion of the question of whether or not to stock) received general approval from the Advisory Group. This is not to say that all group members were totally enthusiastic about promoting stocking, but it is concluded that Advisory Group members agreed that the complexity of the problem justified support of the specific recommendation in question.

According to the code of practice (Turner 1988) one reason for providing a range of optional responses to questions is so that each response from a number of respondents can be quantified in order to obtain a "mean" value of response (further details in Turner 1988). The project has decided not to do this in this instance since it was felt that each potential negative response should be viewed in terms of its own merits; but the system might apply in cases of controversy. In any event, the degree of "positive" responses from the group (if averaged) far exceeds that required under the code in order to support the proposal.

In view of the varied backgrounds and expertise of Advisory Group members, and their established range of "views" on the issues of fish introductions or transfers, the project is gratified that their general response has been favourable. Perhaps more importantly, non have deemed it necessary to adamantly disagree with this section of the report or the recommendations arising here.

APPENDIX

COPIES OF OPINIONAIRES AND RESPONSES TO OPINIONAIRES FROM THE ADVISORY GROUP

These are attached in their original unedited form (except that in the process of editing this report recommendation number 3 on the opinionaires has now become recommendation number 1).

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

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January 3, 1990

Dr. David Coates
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Dear David:

This has been a very interesting experience reviewing the materials you sent. I wish we had the chance to really sit down and discuss them!

I was really impressed with the amount and quality of information you and your colleagues provided, as well as your thoughtful analyses of it. This project must be one of the most extensively studied introduction efforts ever made. It also has made a major contribution to understanding the biota of New Guinea streams, which will certainly be a lasting contribution. I hope you will find the time to edit and combine this material into a book that would be readily available in major libraries as well as to continue to publish separate papers.

As my opinionaires indicate, I agree that some introductions are necessary, especially Tilapia rendalli. I must admit I am not wildly enthusiastic about them as I think alterations and perhaps extinctions of native biota are an inevitable consequence. However, planned introductions, with international blessings, are at least likely to be fewer and less harmful than the unplanned ones that have been perpetrated on so many aquatic systems. I just hope that the government of PNG will limit itself to your recommendations and that follow-up studies will be conducted. Here are some of my other thoughts on the project:

1. I worry that efforts like this will not really do any good in the long run. In a protein-short region, an influx of new, high quality food may stimulate a population increase, with the final result being that there are simply more people who are short of protein and more degraded environment. I realize that this concern is beyond the scope of your project and beyond the planning capabilities of most governments. Perhaps the introduction will help to buy time for PNG to make its entry into the modern world less stressful.

2. I would like to see future efforts focus on considerations of introducing fishes from the Fly River or other streams of New Guinea. I realize that this presents enormous political and logistical

difficulties, not to mention the need to conduct studies on the fishes themselves. However, the results might be worth the effort for the following reasons:

a. My experience is that introduction of species from nearby drainages in North America are less likely to cause extinction of native species than is introduction of exotic species. Shifts in the community (niche compression) occurs but the resulting community is more likely to have long-term stability. Presumably this is because the introduced species is more adapted to local environmental conditions, including the local biota.

b. Introductions of disease are less likely because of previous connections between the waters by way of birds (as intermediate hosts of parasites etc.) and headwater captures.

c. Aesthetically, one could argue that such introductions are an acceleration of natural events, rather than being a radical departure from them as when exotic species are brought in.

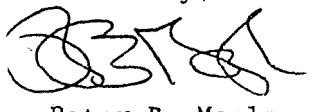
d. The studies of potential introductions would contribute to our understanding of the other systems, increasing the probability that they could be managed better as well.

3. I worry about the possibility of endemic invertebrates being eliminated by the introductions. David Dudgeon's studies are certainly a good start towards understanding the invertebrate fauna, but most identifications are not to the species level. Making the initial introductions herbivores and detrivores also reduces the possibility of invertebrate extinctions. I guess this really just points out the need for more taxonomic studies of the invertebrates (the fishes too!). This, of course, mirrors a worldwide problem: there are few people interested in such studies and few funds to do them in any case.

4. Please avoid using the term "vacant niche." By definition, a niche is a characteristic of an organism, not its environment. When the term "vacant niche" is used you are really referring to resources, such as zooplankton, that are not being used in ways that we fully understand or that benefit humans directly. The term "vacant niche" also implies that introductions can be successfully made that will have no effect on the established biotic communities, something that is highly improbable.

Anyway, I congratulate you and your colleagues on a job well done. You have done more than I would have thought possible under the circumstances.

Sincerely,



Peter B. Moyle

PBM:sc

ADVISORY GROUP OPINIONAIRE RELATING TO RECOMMENDATION ~~3~~ 1 Dwb (Part One - Phase One Report)

NAME: Peter Moyle SIGNATURE: [signature] DATE: 4 Jan. 1990

Please circle one of the responses only for each question.

	Response					
(1) Is the information upon which this recommendation based adequate to justify the recommendation ?	No	Unlikely	Possibly	(Probably)	Yes	Don't know
(2) Do you agree with the recommendation ?	No	Not-sure	(Yes)	Don't know		

You may provide whatever comments you wish as supporting material to the project Chief Technical Advisor for inclusion in the project report to be provided to PNG.

Additional comments provided (YES)/NO (please circle as appropriate).

see attached letter

King's College London
UNIVERSITY OF LONDON
DIVISION OF BIOSPHERE SCIENCES

HEAD OF DIVISION: PROFESSOR P.J.PETERSON
DEPUTY HEAD: DR.C.F.THURSTON

Campden Hill Road
LONDON W8 7AH
Telephone: 01 937 5411
Fax: 01 937 7783

Dr D.Coates
C/O 'Westlin'
Rockcliffe via Dalbeattie
Kirkcudbrightshire
Scotland

22 December 1989

Dear David,

Sepik River Fish Stock Enhancement Project

I have to confess to being a bit overwhelmed by all of the reports and data analysis that this project has generated. I've tried to digest those items relevant to the present proposals and retain the remainder for consideration when further recommendations come up. I would congratulate you on your hard work in generating much of this information and upon organising the material to best effect.

Well, I have now exercised my judgement and I will be interested to learn in due course what the overall concensus of advice has been. Do you expect to stay with the project if / when stocking gets underway ?

Meanwhile I trust that you are enjoying a good break from it all in Scotland.

I expect to back in College from about 3 January but should you wish to contact me at home please do not hesitate. My telephone number is 028 14 3361 (that is Farnham Common 3361).

Season's Greetings and all the best for 1990

Yours sincerely,

Roland.

Roland Bailey

ADVISORY GROUP OPINIONAIRE RELATING TO RECOMMENDATION 1 Blank (Part One - Phase One Report)

NAME: ROLAND BAILEY SIGNATURE: R&Bailey DATE: 22-12-89

Please circle one of the responses only for each question.

	Response					
(1) Is the information upon which this recommendation based adequate to justify the recommendation ?	No	Unlikely	Possibly	Probably	(Yes)	Don't know
(2) Do you agree with the recommendation ?	No	Not-sure	(Yes)		Don't know	

You may provide whatever comments you wish as supporting material [illegible] project Chief Technical A. inclusion in the project report [illegible] be provided to PNG.

Additional comments provided YES/NO (please circle as appropriate).

Am much impressed by the thoroughness of the 'need to stock' appraisal - rarely if ever matched elsewhere.

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MC P.O. BOX 1501, MAKATI, METRO MANILA 1299, PHILIPPINES

18 January 1990

Dr. David Coates
Chief Technical Adviser
United Nations Development Program
Office of the Resident Representative
in Papua New Guinea
P.O. Box 1041
Port Moresby

Dear David,

Many congratulations on the excellent Phase One final report and recommendations. The thoroughness of your distribution of documents is exemplary. I liked the Dudgeon report very much. I enclose my completed `opinionaires´.

In addition, I have the following comments:

1. Why not get a good common carp population genetics group to look at specimens from the PNG stock and describe them thoroughly. The group that I recommend for this is Stefano Cataudella, Donatella Crossetti and Luciana Sola at the University of Rome. You could then decide whether an additional importation of new common carp genetic material would be useful and, if so, and from where it should come. I think also that another introduction of *O. mossambicus* from near its southern limits (most cold-tolerant) could also be useful. You can write to:

    Dr. Stefano Cataudella
    Prof. of Fisheries and Aquaculture
    Department of Biology
    University of Rome
    Tor Vergata
    Via O. Raimundo
    00100 Rome - Italy

    Please say that it was my suggestion if you go ahead.

2. Much as I admire Stirling University´s activities in maintaining pure stocks of tilapias, I would recommend some importations from Africa, if possible. We can possibly help with contacts. I think you would get a broader genetic base from direct transfers from the

2ND FLR., BLOOMINGDALE BLDG.
205 SALCEDO ST., LEGASPI VILLAGE
MAKATI, METRO MANILA 1200
PHILIPPINES

CABLE: ICLARM MANILA
TELEX: (ETPI) 64794 ICLARM PN, 4900010376 ICL UI (USA)
FAX: (63-2) 816-3183
TEL.: 818-0466, 818-9283, 817-5255, 817-5163
E-MAIL: (CGNET) ICLARM, (SCIENCENET) ICLARM.MANILA

wild. This was the view we took for our 'gene' hunting. However, your logistic arrangements have to be good for this and your quarantine arrangements excellent. We ship tilapias from Africa to Asia using the University of Hamburg as a 'staging post'. Perhaps the answer is to do <u>both</u> i.e. collect in Africa, ship to Stirling for initial quarantine, recovery etc. (this would give them new/extra material as well) and then ship to PNG both old and new stocks. You could write to Ron Roberts to explore this. His address is:

Prof. R.J. Roberts
Director of Institute
Institute of Aquaculture
University of Stirling
Stirling FK9 4LA
Scotland, U.K.

We will help all we can with arrangements in Africa if you decide to pursue this, but the funds will have to come from somewhere.

That's all for now. Good luck with all your endeavors.

Best regards.

Yours sincerely,

DR. ROGER S.V. PULLIN
Director
Aquaculture Program

Enclosure - 'opinionaires'

RSVP/emr*

ADVISORY GROUP OPINIONAIRE RELATING TO RECOMMENDATION ~~3~~ 1 (Part One - Phase One Report)

NAME: ROGER S.V. PULLIN SIGNATURE: R S V. Pullin DATE: 17/1/90.

Please circle one of the responses only for each question.

	Response					
(1) Is the information upon which this recommendation based adequate to justify the recommendation ?	No	Unlikely	Possibly	(Probably)	Yes	Don't know
(2) Do you agree with the recommendation ?	No	Not-sure	(Yes)	Don't know		

You may provide whatever comments you wish [illegible] supporting material to the [illegible] Chief Technical Adviser [illegible] inclusion in the project report to be provided to PNG.

Additional comments provided YES/(NO) (please circle as appropriate).

डा० कृष्ण लाल सहगल
परियोजना निदेशक
Dr. K. L. SEHGAL
Project Director

तार : माहसीर
Grams : MAHSEER
टेलीफोन कार्या. : 445
Office : 445
निवास : 330
Resi. : 330

राष्ट्रीय ठंडापानी मत्स्यकी अनुसंधान केन्द्र (भा० कृ० अनु० प०)
शिल्वा हिल्स नर्सरी, रुपनगर, पोस्ट बाक्स नं० २८,
हल्दवानी-२६३ १३९ जि० नैनीताल (उ०प्र०)
National Research Centre on Coldwater Fisheries (I. C. A. R.)
Shilwa Hills, Nursery, Roopnagar, Post Box No. 28,
Haldwani-263 139 Distt. Nainital (U. P.)

BY AIR MAIL

No.F. 4-4(19)/89/DC/2413 December 18, 1989.

Dear Dr. Coates,

I write to refer to your letter of 30th October, 1989 alongwith the enclosures. The receipt of the letter has already been acknowledged through a telex message. As desired therein, I am sending separately four opinionaires duly filled in. I am enclosing one copy of the opinionaires for your necessary action. The second copy is being posted to Dr. T. Petr, FAO Fisheries Department, FAO, Rome through FAC Representative in India by diplomatic pouch. I am also enclosing a brief note on my views regarding introduction of T. rendalli. In case you feel useful the information may be incorporated.

Regarding Part.II/Phase.I of Final Report, I am preparing a detailed note on my views pertaining to non-flood plain regions of the Sepik and the proposed introduction of various categories of coldwater fish species. This note will provide additional information on different aspects of researches carried out in India on Schizothoracids, mahseers (Tor spp.), trouts and Crossocheilus, etc.

With regards and Happy Christamas and New Year.

Yours sincerely,

(K.L.SEHGAL)

Encl: As above.

Dr. David Coates,
C/o Westlin,
Rockliffe, via Dalbeattie,
Kirkcudbrightshire, Scotland, U.K.

ADVISORY GROUP OPINIONAIRE RELATING TO RECOMMENDATION 1 (Part One - Phase One Report)

NAME: DR. K.L. SEHGAL SIGNATURE: _____ DATE: 18 December 1989

Please circle one of the responses only for each question.

	Response					
(1) Is the information upon which this recommendation based adequate to justify the recommendation ?	No	Unlikely	Possibly	Probably	(Yes)	Don't know
(2) Do you agree with the recommendation ?	No	Not-sure	(Yes)		Don't know	

You may provide whatever comments you wish as supporting material to the project ... of Technical Adviser for inclusion in the project report to be provided to PNG.

Additional comments provided YES/NO (please circle as appropriate).

RESEARCH INSTITUTE FOR FRESHWATER FISHERIES
AGENCY FOR AGRICULTURAL RESEARCH AND DEVELOPMENT

Our Ref : KS. 1.40.29.1.90
Your Ref :

Bogor, 8 January 1990

1, Jalan Sempur
P.O. Box - 51
Bogor - Indonesia
Phone : (0251) 22200
Cable : Balitkanwar

Dr. David Coates

Chief Technical Adviser
Sepik River Fish Stock
Enhancement Project
FAO Fisheries Development
R O M E

Dear Dr. Coates,

I am pleased to send you my response on opinionaire for the Sepik River Fish Stock Enhancement. I regret to inform you that I have no experience at all with both Tilapia rendalli and T. zillii, sp my response of the species is not satisfactory.

I hope my opinion on the recommendation for the introduction of T. rendalli and the transfer of Trichogaster pectoralis and Osphronemus gouramy will be contributing for the decission making.

In this occession I wish you all the best for a prosperous new year, 1990.

My best regards

Yours sincerely

Atmadja Hardjamulia
Director

CC :

ADVISORY GROUP OPINIONAIRE RELATING TO RECOMMENDATION 2 (Part One - Phase One Report)

NAME: A. HARDJAMULIA SIGNATURE: _____ DATE: 28 DECEMBER, 1989

Please circle one of the responses only for each question.

	Response					
(1) Is the information upon which this recommendation based adequate to justify the recommendation ?	No	Unlikely	Possibly	Probably	(Yes)	Don't know
(2) Do you agree with the recommendation ?	No	Not-sure	(Yes)		Don't know	

You may provide [illegible] comments you wish as supplementary [illegible] to the project [illegible] inclusion in the [illegible] report to be provided to PM.

Additional comments provided YES/(NO) (please circle as appropriate).