AN APPRAISAL OF STOCKING STRATEGIES IN THE LIGHT OF DEVELOPING COUNTRY CONSTRAINTS

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ABSTRACT

Stocking, transfer and introduction of fish are commonly used to mitigate loss of stocks, enhance recreational or commercial catches, restore fisheries or to create new fisheries. However, many stocking programmes are carried out without definition of objectives or evaluation of the potential or actual success of the exercise. This paper describes a strategic approach to stocking aimed at maximising the potential benefits. A protocol is discussed which reviews factors such as source of fish, stocking density, age and size of fish at stocking, timing of stocking and mechanism of stocking. Finally, the effects of social, cultural and economic constraints on the potential outcome of stock enhancement programmes are discussed.

1. INTRODUCTION

The enhancement of fisheries through the stocking of individuals or introduction of species is a practice frequently used by fisheries owners, managers and scientists, throughout the world (Cowx, 1994; Welcomme, 1997). Many thousands of stocking events, involving millions of individual fish, take place annually in managed fisheries (Hickley, 1993). In some cases the justification for these activities is perfectly acceptable, for example, to compensate for loss due to environmental interventions such as pollution, river engineering or a manmade obstruction to migration such as a dam, or to enhance fish yield. However, despite there being national and international regulations and codes of practice on species that can be stocked and criteria to minimise any transfer of disease, in many cases there appears to be little control over whether the stocking activity is appropriate or necessary. More recently, concerns have also been expressed about the potential risks associated with stocking of fish, particularly with respect to ecological imbalance and change in community structure, and loss of genetic integrity (Cowx, 1994; Carvalho and Cross, 1997).

Notwithstanding, examples of stocking fish in inland waters in the literature are sparse, mainly because the outcome is rarely documented, but also because many stocking programmes have not proved to be successful (Cowx, 1997). In developed countries the most successful stock enhancement programmes have been associated with put-and-take and intensive recreational fisheries (e.g. Moehl and Davies, 1993). By contrast, successful programmes in developing countries appear to be associated with reservoir fisheries which have been heavily stocked to increase yield, e.g. India (Sugunan, 1995), Cuba (Fonticiella et al., 1995) and China (Lu, 1992). It should be noted that the activities carried out in China are not strictly stocking as they further enhance production through fertilisation of the water and supplementary feeding, so it is more akin to extensive aquaculture. Not all enhancement programmes are successful. For example, stocking of carps in the perennial reservoirs of Sri Lanka has proved to be ineffective and the reservoirs are now being managed mainly for self-reproducing tilapias (Amarasinghe, 1997). Stocking of river fisheries has met with limited success, except perhaps the salmonid fisheries in Europe, North America and Japan (Cowx, 1997), and some floodplain fisheries, e.g. Lempuing River in Sumatra (Hall, 1994).

The general consensus is that stocking is a much used, but all too often abused, tool in fisheries management. This is partly because of the preconception that stocking will improve yields from fisheries. However, there is considerable evidence to suggest this is not the case unless the stocking activity is well managed, and takes into account many of the wider issues that may impinge on the outcome of the stock enhancement exercise. This paper outlines the main issues and options that should be considered before a stocking programme is initiated and recommends a protocol to evaluate and improve the effectiveness of stocking as a management tool, particularly with reference to the constraints imposed in developing countries.

2. OBJECTIVES OF STOCKING

Stocking of fish into natural habitats is generally in response to degraded wild fish stocks caused by habitat change, or to over-exploitation; or to enhance fish yield where production is below that predicted. In this context, stocking is an attempt to fix a problem, either real or perceived. Depending on the problem, stocking can be considered to be either a permanent or temporary solution and can, more-or-less, be divided into four main categories.

2.1 Stocking for mitigation

This encompasses stocking with fish carried out as a voluntary exercise or statutory function for fishery protection schemes, such as in reservoir dam construction, land drainage works or similar perturbation. Mitigation stocking is considered the simplest way to compensate for such activities. However, stocked fish may be released into unaffected parts of the river catchment or lake, and the impact on the wild stocks in these areas must be considered. In this situation, stocking is a permanent solution and is unlikely to lead to a self-sustaining natural population because the underlying reason for the stocking has not been removed. This type of stocking activity is restricted mainly to developed countries. In developing countries the general philosophy appears to err towards the environmental and economic gain from the water resource development schemes which are considered to more than compensate for a loss to the natural fishery. This is particularly the case with respect to reservoirs where the preconception is that the yield from the fishery in the newly created water body will be far greater than the existing river fishery. However, there are many examples to suggest this is not necessarily the case, e.g. Kainji (Ita, 1984) and Itezhi-tezhi (Kapasa and Cowx, 1991).

2.2 Stocking for enhancement

Enhancement stocking is the principal method used to maintain or improve stocks where production is actually, or perceived to be, less than the water body could potentially sustain, but where reasons for the poor stocks cannot be identified. This type of stocking is used where those exploiting the fishery have expressed dissatisfaction with the quality of fishing, or to enhance stocks in sections of river where access is restricted by natural barriers, or in the operation of commercial or put-and-take fisheries where the production of exploited species needs enhancing. It also includes activities carried out to strengthen quality and quantity of spawning stock of a given species so as to improve natural reproduction potential.

The majority of stocking programmes in the past probably fall into this category and they are frequently driven by complaints about the status of the fishing. However, in many cases the assessment of the state of the stock has been unduly pessimistic, resulting from natural fluctuations which can have profound effects on some fish populations, or the estimates of the potential production have been unrealistically high. If production is already limited or driven by natural population cycles, it is unlikely that stocking will have a beneficial, long-term effect. In developing countries the objectives are very different and driven by the need to improve available food resources and generate income. When stocking for enhancement is considered a permanent solution, it can be defined as ranching or, in the case of sport fishing, ‘put-and-take’. As a permanent solution, the strategy requires continuous application to maintain the desired fishery.

2.3 Stocking for restoration

Stocking for restoration relates to that which is carried out after a limiting factor to stock recovery or improvement has been removed or reduced, e.g. water quality improvement, habitat restoration, the easing of passage for migratory fish or management of fishing pressure. Re-

establishment of fisheries which have previously been eliminated by poor water quality or habitat degradation fall into this category. Stocking in this case is justifiable because the underlying problems limiting production have been tackled and long-term benefits are likely to accrue. Stocking programmes of this type should be a temporary measure and require a more active management strategy for the aquatic ecosystem and the fish populations. Management can be in the form of control over the exploitation of the fishery or habitat manipulation, or both. The ultimate objective is to create a fish stock and aquatic ecosystem that are self sustaining.

2.4 Creation of new fisheries

This category includes attempts to establish a new stock of fish in a river, lake or reservoir which has not previously held that stock because of natural barriers or evolutionary isolation, or where new (exotic) species are introduced into existing fisheries in an attempt to increase species diversity, improve fish yield or fill an apparent vacant niche. This is the most controversial stocking procedure and has led to considerable contention in the past, e.g. the introduction of Nile perch, *Lates niloticus* L., into Lake Victoria (Okemwa and Ogari, 1993; Lévêque, 1997). However, if the new species is able to occupy a vacant niche the impact on the indigenous species may be negligible and the introduced species may become a valuable addition to the fishery, e.g. the introduction of *Limnothrissa miodon* (L.) into Lake Kariba (Hauser, Carvalho and Pitcher, 1997). Consequently, stocking of this type needs careful planning to avoid potential catastrophic effects on the natural fish populations. The issues associated with this type of activity are discussed more fully by Welcomme (1997) and Coates (1997). This type of activity generally falls under the definition of introductions and will not be discussed further, but the reader is referred to Cowx (1997).

3. STOCKING STRATEGIES

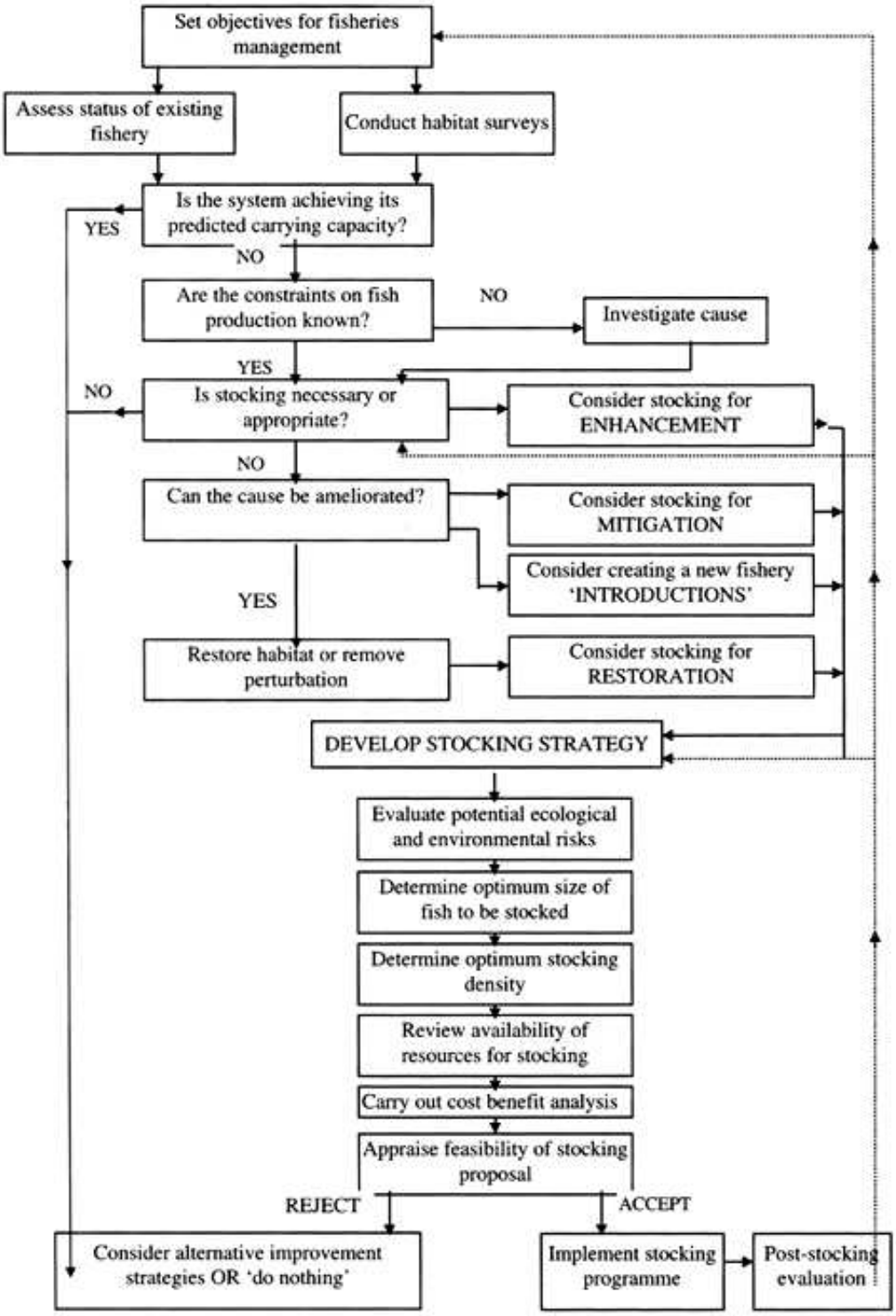
Guidelines for stocking fish are available in many developed countries. These are often species specific or relate to particular types of water bodies. The main issues and options covered in these guidelines were summarised by Cowx (1994) and are illustrated in Figure 1. This step-wise approach to planning and implementing a stocking programme ensures that the main ecological and practical aspects are addressed at an early stage.

Essentially the strategies attempt to identify the objectives for the stocking programme, the mechanisms by which they will be carried out, and the potential ecological and environmental risks. Appropriate implementation strategies are essential if the stocking programme is to be successful. The issues that must be considered include: source of fish; whether the fish to be stocked should be preconditioned or acclimatised; handling and transportation of fish to the stocking site; stocking densities; age or size of stock; timing of stocking and mechanisms of release. All these aspects must be taken into account at the planning stage of the stocking exercise to maximise the benefits and minimise any potential risks. In particular, broodstock for artificial propagation of stocking material should be either from: i) the water body to be stocked; ii) a donor stock with the same biological characteristics as the recipient system; or iii) a population from a water body with similar environmental characteristics. The stocking density should be based on qualified scientific evaluation of the characteristics of the fishery (Amarasinghe, 1997). All too often too many fish are stocked into the water body and this leads to negligible change or a deterioration of the existing fishery. To determine the stocking density the ecological characteristics of the water body should be assessed using empirical models (e.g. Li and Xu, 1995; Lorenzen, 1995) or indices such as the morpho-edaphic index or habitat suitability index (Welcomme, 1976, 1997; Amarasinghe, 1997). In addition there are now well-defined protocols to ensure the fish to be stocked are in good condition at the time of stocking. These must be followed to ensure the fish have the best chance of survival. This includes the mechanism and timing of stocking, because evidence suggests that frequent planting of small numbers of fish on a continuous basis throughout the water body to be enhanced (trickle stocking) improves the stocking success, presumably through reduced competition with, or predation by, the natural fish stocks (e.g. Fjellheim, Raddum and Sægrov, 1994; Berg and Jørgensen 1994).

Amongst the consequences of stocking are reduction of stock fitness through genetic introgression (Allendorf, Ryman and Utter, 1987; Carvalho and Cross, 1997), transfer of diseases (Kennedy, 1993), competitive interactions with other species and the effects on ecosystem trophic dynamics such as predation and habitat alteration (Cowx, 1997a).

Finally, any stocking strategy must include a post-stocking monitoring programme to measure the success of the intervention. Any measure of the success of a stocking programme will depend on the extent to which its objectives are realised. These may be very variable, for instance in stocking of commercial fisheries the usual measure is the extent to which the financial value of the catches is improved, whereas in a recreational fishery the criterion is a more elusive one of angler satisfaction.

Figure 1. Suggested strategy for evaluating a stocking programme to minimise the potential risk, maximise the potential benefit and monitor the success of the project (from Cowx, 1994)



Unfortunately, stocking programmes are frequently unsuccessful, curtailed or merely abandoned because the wider political, social and economic issues associated with fisheries management are ignored. This is particularly true in developing countries where the overall fisheries sector objectives are different from those in developed regions of the world. In developed countries

stocking strategies are targeted towards ecological goals, particularly the enhancement of recreational fishing, and more recently conservation and protection of species diversity (Cowx, 1997b). In developing countries the needs are economically driven, focusing on food security and income generation. The differing needs mean that the issues and constraints acting on fisheries enhancement activities in developing countries are very different and the strategies formulated for these regions need adapting to the prevailing circumstances in developing countries. A summary of the issues and constraints that must be taken into account if stocking is to be successful is given in the next section.

4. ISSUES AND CONSTRAINTS

Although most stocking activities can be categorised into the broad objectives outlined above, the potential for a successful outcome is often limited because the specific objectives of the exercise in relation to perceived problems and available resources are not fully appraised from the onset. Many projects are ill conceived and do not fully address the issues which have led to the requirement to improve the fishery and possible constraints on the enhancement procedures adopted. Furthermore, they often have little consideration for wider cross-sectoral and environmental issues, particularly in relation to long-term impacts.

The main problem lies in poor or improper planning and evaluation of the proposed stocking activity. Before any resources are invested, a full prefeasibility study should be carried out and the stocking programme should be linked to the sectoral objectives, not just the fishery objectives. From the sectoral perspective, the objectives of stocking can be considered a compromise between conservation and protection of the ecosystem, positive economic return, and food security and/or employment. However, there is one fundamental issue that is often neglected before a stocking programme is undertaken. “Why does the fish stock need enhancement?” It is a question that is rarely answered before a stocking programme takes place because it is often a reflection of poor management of the environment or the fish stocks themselves. Stock enhancement is frequently required because the fishery has been over exploited in the past or suffered some environmental perturbation. In many instances the issue that should be addressed is whether the constraints acting on the fishery can be removed and the fishery can be enhanced based on natural production.

This issue is particularly pertinent where overfishing is prevalent or environmental degradation has occurred. In small-scale artisanal or subsistence fisheries where the catch is removed, as is frequently the case in developing countries, improved management should be the option considered first. The use of community based management strategies (Ahmed et al., 1997), whereby the responsibility for the fishery is developed to the local people, should also be considered. This must obviously be backed up by well informed extension activities and monitoring.

Removal of any recruitment bottleneck associated with environmental degradation also needs early evaluation. If mitigatory action against the factors causing the poor recruitment to the fishery is not addressed at an early stage stocking will have to be a long-term solution to the problem. Although this may initially appear a cost-effective option, in the long term, recurrent costs, and resource needs to meet any criteria for stocking can become a problem as the focus of financial support and political/economic conditions change. Notwithstanding, this option does not address the fundamental issue: ‘What is causing the decline in fisheries potential yield?’

To address the fundamental causes for the poor status of the fish stocks in the first instance has added benefit because a stocking programme is more likely to succeed if bottlenecks to natural recruitment are removed. Without such action, any benefits accrued from the stocking programme are likely to be dissipated quickly and stocking will have to be done on a continuous basis.

As previously discussed, most stocking strategies generally concentrate on fishery-related aspects such as size of fish, density or biomass of fish to be stocked, stocking period, source of fish, preconditioning, transportation to the stocking location and mechanism of release (i.e. spot, scatter or trickle stocking; see Cowx, 1994 for details). However, there are many wider issues and constrains that also need overcoming before a stocking activity can take place or will be effective, particularly where fisheries are maintained by regular stocking, i.e. commercial culture-

based fisheries. These can be broken down into two main areas: provision of stocking material and management of the fisheries.

In many cases failure to maintain fish stocks at adequate levels in culture-based fisheries arises because of lack of suitable stocking material. A recurring problem is that fish are not available at the ideal time or in the numbers required. The problem can be traced back to the source of supply of the seed or fish for stocking. Many culture-based fisheries are based on stocking material from the wild or fish farms. Seed from the wild are often subject to huge natural fluctuations which inevitably affects availability. If the fishery is dependent on this source, and stocks are limited, the stocking programme can fail. Similarly, supply of stocking material from fish farms or hatcheries can also have inherent problems. Many of the suppliers, in developing countries in particular, are government-funded facilities. These only have limited capacity and increasing demand for stocking material can outstrip supply. Notwithstanding hatcheries and farms are often in central locations and access to the fishery is difficult and creates transportation and logistic problems.

Ideally the fish farms should be established in each district where demand is high, but this may put undue stress on the often overstretched resources of the government department, both in relation to financial implications and trained personnel. Reliance on this source of stocking material is therefore not optimal.

Furthermore, the reliance of many culture-based fisheries on government support provided through, for example, supply of stocking material or financial subsidies, can be problematic. This encourages many fisheries managers/owners not to become self-sufficient and it can result in yield below that expected because proper management measures are often not implemented to complement the stocking. This outcome generally conflicts with the objective of this type of stocking exercise which is to improve food security. In addition, there are many external influences which may affect the long-term success of these types of activities. These include: political and economic instability; changes in fisheries sector objectives; shifts in environmental awareness; change in aquatic resource use; - all of which may change the support for the programme.

To minimise these problems it is recommended that support for stocking programmes be provided for a limited period only (preferably 3–5 years) to encourage self sufficiency. This will inevitably mean that revolving credit schemes or other financing will have to be made available through rural development programmes, and adequate extension and advisory services will have to be put into place. In addition, the risk of failure can be dissipated through the establishment of co-operatives or other suitable community-based management initiatives.

The move towards self reliance raises the issue of cost effectiveness of the stocking programme. Generally it would be expected that all stocking programmes should be economically viable and contribute to the well-being of the stocks (Langton and Wilson, 1997; Welcomme, 1997). Unfortunately financially-driven enhancement programmes are rarely successful because the returns in terms of increased yield (revenue) do not usually cover the costs of the stocking programmes. This is clearly seen by the numerous stocking programmes that have been abandoned (Cowx, 1997). Perhaps the exceptions to this are put-and-take fisheries and intensively stocked sport fisheries where people pay high fees to guarantee to catch fish.

In principle, stocking programmes should not necessarily be based on financial return alone. In many parts of the world the principal objectives are food security and employment, and if the fisheries achieved these then it must be considered a success. Similarly, stocking to enhance or rehabilitate fisheries in the long term has important environmental and political roles, not only those contributing to improvement of the general status of the fisheries but also maintaining the improvements. This issue is exemplified by the River Thames (UK) Salmon Restoration Scheme which has considerable environmental spin-offs, particularly the public perception that the river is now clean and the increased responsibility of water users to ensure this status is maintained. There is no reason why similar rehabilitation programmes cannot be instigated in developing countries to promote environmental awareness.

Another issue is ownership. In water bodies where the boundaries can be defined, e.g. put-and-take and still water fisheries, this is not a problem. In open systems, such as large rivers, lakes or

coastal regions, the ownership is less well defined. In these systems stocking is more akin to ranching and the dispersion of stocked fish outside the area of jurisdiction of those carrying out the stocking programme puts considerable question on ownership and exploitation rights. In many instances the stocked fish become a common property resource and any stocking programme will probably have to sustain any external exploitation. This is the reason why many ranching programmes do not succeed on a strictly financial basis because the return on investment is dissipated and not accrued by the primary owner. Under such circumstances the programmes generally have to be run by a central institution, and if the objective is to run an economically viable fishery a levy or license fee needs to be paid by those exploiting the fishery to cover the costs. Alternatively, if the objective is food security then the institution may accept the cost, but the fishery will probably require some form of regulation to prevent overfishing. Community-based management or licensing systems such as those discussed previously are probably the best strategies for this regulatory control.

5. CONCLUSIONS AND RECOMMENDATIONS

Stocking is an important tool in the management of fisheries, albeit for commercial, recreational or conservation purposes. However, the management rationale and implications of stocking activities have not received the attention desired to support such a commonly used tool. It is recommended that a strategic planning approach to stocking, similar to that which is summarised in Figure 2, is adopted. This expands on the issues raised by Cowx (1994; Fig. 1) and draws the attention of the manager to the many problems that must be resolved within a wider fisheries sectoral context before a stocking programme is likely to achieve its objectives. As part of this approach a number of aspects should be considered at an early stage.

- Whenever stocking of fish is to be considered, the aims, and specific objectives of the exercise must be clearly defined and adhered to.
- Before any stocking programme is undertaken a thorough evaluation of the reasons for the action should be examined and alternative approaches to enhancement, e.g. habitat improvement or better fisheries management, should be attempted where possible.
- The wider issues and constraints that are likely to affect the long-term success of the stocking programme should be reviewed and considered in the design of any enhancement project.
- When evaluating stocking as a possible management tool, the relative benefits and cost of all options should be considered. The “do nothing” option should not be disregarded but should be considered as fully as any of the other options under discussion, despite possible public pressure to stock.
- The strategy for any programme of stocking, transfer or introduction should be carefully tailored to suit the species in question, taking into account its entire suite of ecological prerequisites, so as to maximise the chances of success.
- The potential adverse impacts of stocking in terms of environmental, genetic and ecological interactions should be considered fully and the ‘precautionary principle’ adopted if any adverse impacts are foreseen.
- All projects should have in place the methodology to enable adequate monitoring of progress, and ultimately, success or failure. This post-stocking appraisal should include a mechanism of disseminating the outcome to minimise the risk of any unforeseen adverse effects in future exercises.
- A series of guidelines should be produced for all species which are stocked or introduced, clearly defining the most effective protocol for deciding whether stocking should take place, how it should be implemented and the potential impacts of such activities.

When assessing the viability of a stocking programme an evaluation of the most cost effective options in relation to expected benefits should be undertaken, particularly in developing countries where resources are at a premium. All too often the strategy is to make do with existing resources, whereas a little forward planning may increase the output considerably. For example, the return from stocking is affected by the size (development stage) of the fish released and it is generally known that yield from juveniles is higher than from larvae and larger fish (Cowx, 1994; Fig. 3a). The yield from stocking larvae is also unpredictable and highly variable (due to stochastic environmental factors) while that from juveniles and sub-adults can be adjusted to a high degree (density-dependent survival and growth).

Figure 2. A scheme for planning stocking programmes. Review boxes on the left illustrate the different levels of data collection and processing and decision boxes on the right the respective decision levels with some relevant questions. Stocking should be rejected if any answers to the questions are unacceptable (adapted from EIFAC, 1994).

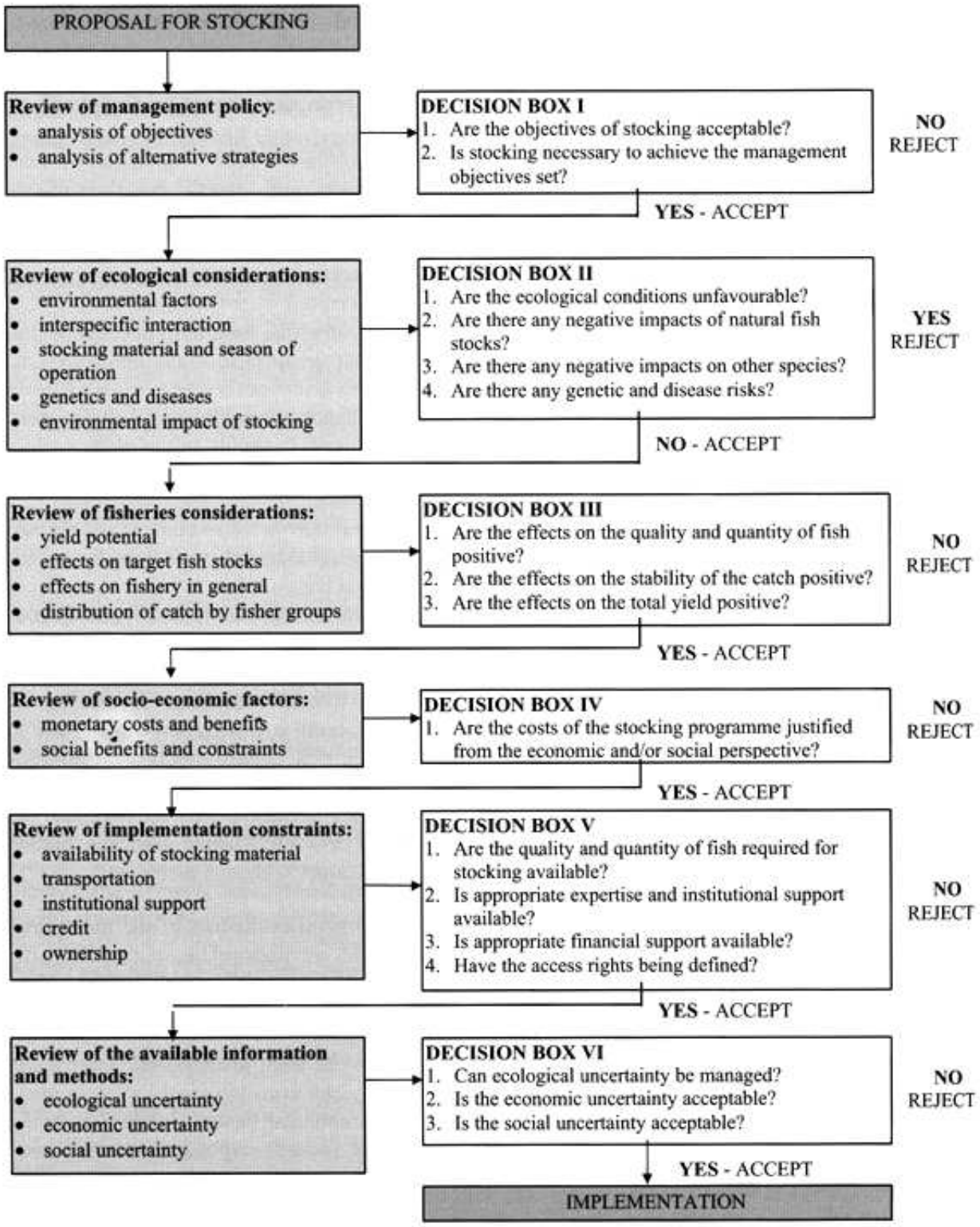
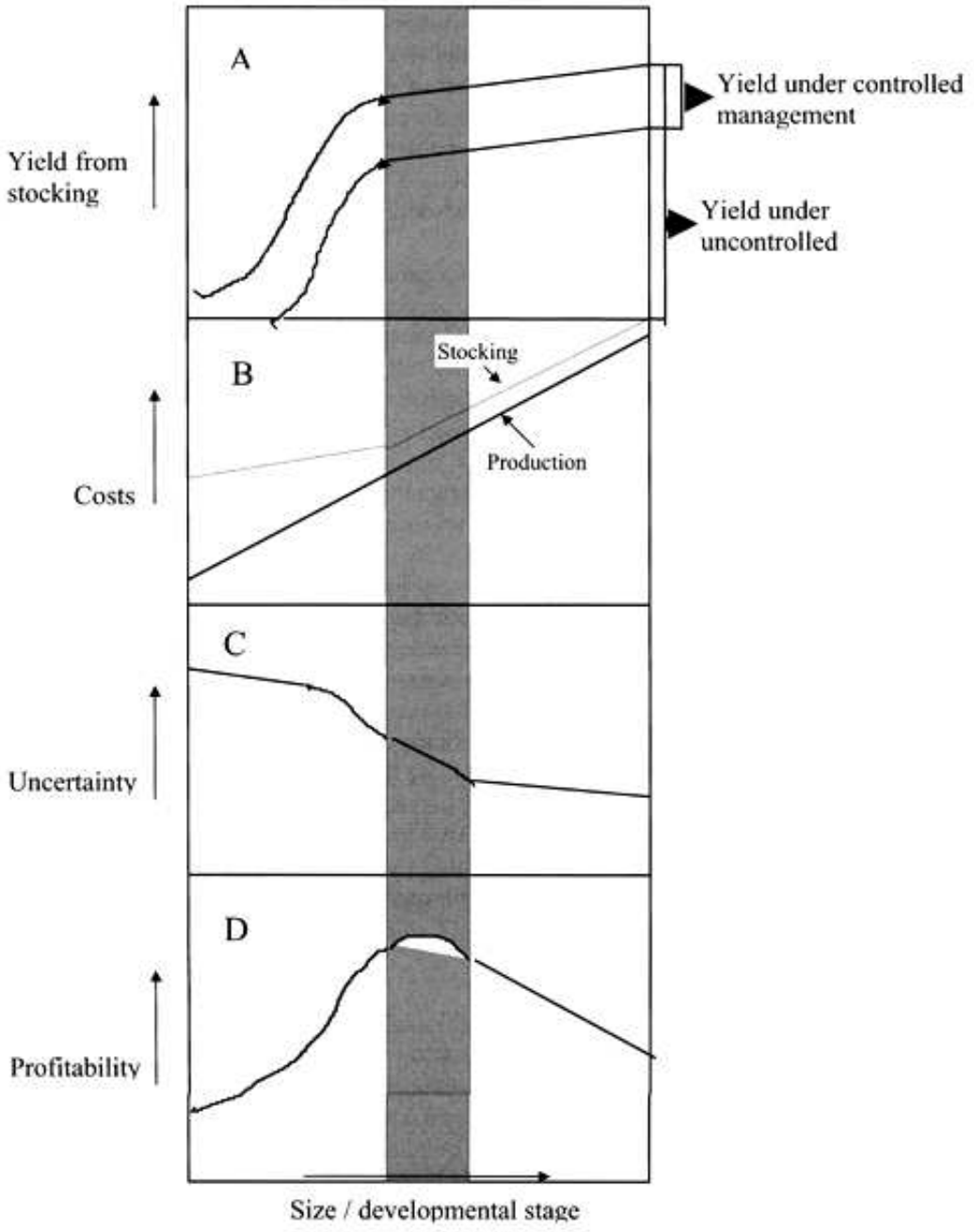


Figure 3. Hypothetical optimum size of fish from economic perspective. The shaded area shows the optimum size. A) Range of yields from stocking under controlled and uncontrolled management. B) Production costs (production), a function of fish size and stocking costs/unit of additional catch (*stocking* = *number released* × (*production costs* + *transportation and other stocking costs*)). C) Uncertainty of the yield from stocking in relation to size of fish released. D) Profitability of stocking in relation to the size of fish released. (Modified from EIFAC, 1994).



Production costs of fish released is generally a function of fish size (Fig. 3b), but stocking costs increase rapidly and non-linearly because fewer fish are needed to obtain the same amount of additional catch from stocking when the size of released fish is increased. However, this must be balanced against the uncertainty in fishery yield (and hence economic uncertainty) from stocking which decreases as a function of fish size (Fig. 3c). It generally is thought that there is a transition size (juvenile bottleneck) after which the yield from stocking is changed from unpredictable to predictable and the uncertainty is lowered considerably.

In principle, the size that optimises the yield from stocking (benefits) in relation to stocking costs, with a minimum of economic and social uncertainty, should be preferred. The optimum size to give the maximum benefit should be determined for all stocking programmes. In a fishery where the exploitation is well managed, and the fish allowed to achieve a reasonable size before being exploited, the optimum size is probably somewhere in the early juvenile stages (Fig. 3d). However, if the fisheries are poorly managed, and the exploitation of young fish is intense, this point is probably in the larval stage because production costs of the stocking material are much lower.

The main problem that exists is that the social or ecological benefits that often accrue cannot easily be expressed in monetary terms. Consequently some measure for achieving the sectoral objectives of food security or employment needs to be applied. It should also be noted that some dis-benefits may also arise out of a stocking programme. For example, well stocked fisheries

often results in increased subsistence fishing activity which elevates fishing pressure and can marginalise the benefits to those fishing full-time who may have borne the costs of stocking and incur both economic loss and reduced employment opportunity. This illustrates the need for community based management of the fisheries resources (Ahmed et al., 1997) to go hand-in-hand with any stocking programme.

It is recommended that all stock enhancement programmes be properly formulated and planned before an implementation activity to avoid indiscriminate and often futile stocking activities. The expected output for the particular stocking exercise should be compared with the wider fisheries sector objectives and the constraints which are likely to restrict the successful outcome should be considered in any appraisal. To this end, practical manuals and guidelines for stocking various fish species in a range of types of water body to meet specific objectives, such as those produced by EIFAC (1994) for coregonids, should be drawn up and made available through government extension services and international advisory bodies. Finally, it is recommended that all stock enhancement programmes, existing as well as proposed, be independently assessed to ensure that the wider environmental, ecological and socio-economic issues have been thoroughly reviewed.

REFERENCES

Ahmed, M., A.D. Capistrano and M. Hossain. 1997. Fisheries co-management in Bangladesh: experiences with government organization - non-government organization -fisheries partnership models. Fisheries Management and Ecology. (In press).

Allendorf, F.W., N. Ryman and F.M. Utter. 1987. Genetics and fishery management - past, present and future. In: Population Genetics and Fishery Management (Ryman, N. and F.W. Utter, eds.): 1–19. University of Washington, Seattle.

Amarasinghe, U.S. 1997. How effective are the stocking strategies for the management of reservoir fisheries of Sri Lanka? In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Berg, S. and J. Jørgensen. 1992. Stocking eel (*Anguilla anguilla*) in streams. In: The Rehabilitation of Freshwater Fisheries (Cowx, I.G., ed.): 314–325. Fishing News Books, Blackwell Scientific Publications, Oxford.

Carvalho, G.R. and T. Cross. 1997. Enhancing fish production through introductions and stocking: genetic perspectives. In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Coates, D. 1997. Codes of practice for the stocking and introduction of fish. In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Cowx, I.G. 1994. Stocking strategies. Fisheries Management and Ecology 1: 15–31

Cowx, I.G. (ed.). 1997a. Stocking and Introduction of Fish. Fishing News Books, Blackwell Science, Oxford.

Cowx, I.G. 1997b. L'introduction d'espèces éstrangères de poissons dans les eaux douces européennes: succès économiques ou désastre écologique? Bulletin Francais de la Peche et de la Pisciculture. (In press).

Cowx, I.G. 1997c. Are there alternatives to stocking and introductions in stock enhancement programmes? In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

EIFAC. 1994. Guidelines for stocking coregonids. FAO EIFAC Occasional Paper. 15p.

Fjellheim, A., G.G. Raddum and H. Sægrov. 1993. Stocking experiments with wild brown trout (*Salmo trutta*) in two mountain reservoirs. In: Rehabilitation of Freshwater Fisheries (Cowx, I.G., ed.): 268–279. Fishing News Books, Blackwell Scientific Publications, Oxford.

Fonticiella, D.W., Z. Arboleya and G. Diaz. 1995. La repoblacion como forma de manejo de pesquerias en la acuicultura de Cuba. FAO COPESCAL Documento Ocasional 10: 45p.

Hall, J.C. 1994. Equity in the fishery: an example from the Lempuing River, south Sumatra, Indonesia. Centre for Development Studies, University of Bath, UK. 14p.

Hauser, L., G.R. Carvalho and T.J. Pitcher. 1997. Genetic similarity of a phenotypically divergent population of the clupeid *Limnothrissa miodon* following its introduction into a man-made lake. In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Hickley, P. 1993. Stocking and introduction of fish - a synthesis. In: Rehabilitation of Freshwater Fisheries (Cowx, I.G., ed.): 247–254. Fishing News Books, Blackwell Scientific Publications, Oxford.

Ita, E.O. 1984 Kainji (Nigeria). In: Status of African reservoir fisheries (Kapetsky, J.M. and T. Petr, eds). FAO CIFA Technical Paper No 10: 43–103.

Kapasa, C. and I.G. Cowx. 1991. Post-impoundment changes in the fish fauna of Lake Itezhitezhi, Zambia. Journal of Fish Biology 39: 783–793.

Langton, R. and W. Wilson. 1997. Are there alternatives to stocking and introductions in stock enhancement programmes? In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Lévêque, C. 1997. Consequences of fish introductions in African fresh waters. In: Stocking and Introduction of Fish (Cowx, I.G., ed.). Fishing News Books, Blackwell Science, Oxford.

Li, S. and S. Xu. 1995. Capture and culture of fish in Chinese reservoirs. IDRC, Ottawa. 125p.

Lu, X. 1992. Fishery management approaches in small reservoirs in China. FAO Fisheries Circular No. 854: 69p.

Lorenzen, K. 1995. Population dynamics and management of culture-based fisheries. Fisheries Management and Ecology 2: 61–73.

Moehl, J.F., Jr and W.D. Davies. 1993. Fishery intensification in small water bodies: a review for North America. FAO Fisheries Technical Paper No. 333: 44p.

Okemwa, E. and J. Ogari. 1993. Introductions and extinctions of fish in Lake Victoria. In: Rehabilitation of Freshwater Fisheries (Cowx, I.G. ed.): 326–337. Fishing News Books, Blackwell Scientific Publications, Oxford.

Sugunan, V.V. 1995. Reservoir fisheries of India. FAO Fisheries Technical Paper No. 345: 423p.

Welcomme, R.L. 1976. Some general and theoretical considerations on the fish yield of African rivers. Journal of Fish Biology 2: 7–24.

Welcomme, R.L. 1997. Evaluation of stocking and introduction as management tools. In: Stocking and Introduction of Fish (Cowx, I.G. ed.). Fishing News Books, Blackwell Science, Oxford.