RESEEDING OF GRAZING GASTROPODS AND BIVALVES INTO THE MARINE ENVIRONMENT IN WESTERN AUSTRALIA

A DISCUSSION PAPER

by
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FISHERIES MANAGEMENT PAPER No. 162

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OPPORTUNITY FOR PUBLIC COMMENT

This discussion paper has been prepared to encourage public involvement in the development of policy for reseeding of grazing gastropods and bivalves. Reseeding may be possible in either existing fisheries or through translocating fish to seed a new fishery. In assessing the translocation of any aquatic species, the economic and social benefits must be balanced with biological and environmental risks.

Comments about this discussion paper are sought from all stakeholders, including commercial and recreational industry members, existing and potential aquaculture farmers, relevant community interest groups, government agencies and interested members of the public.

Following consideration of the public comments received on this discussion paper, a policy paper will be developed which will enunciate the application and assessment processes for reseeding of grazing gastropods and bivalves in Western Australia.

To ensure your submission is as effective as possible, please:

1. make it clear and concise;

2. list your points according to the topic sections and page numbers in this paper;

3. describe briefly each topic or issue you wish to discuss;

4. state whether you agree or disagree with any or all of the information within each topic or just those of specific interest to you. Clearly state your reasons, particularly if you disagree, and give sources of information where possible; and,

5. suggest alternatives to address any issues that you disagree with.

Although this paper is presently focusing on grazing gastropods and bivalves, you are encouraged to provide comment in relation to other species that may be of interest in the future as this will assist in development of policy for these species. In doing so, please keep in mind the definitions adopted for reseeding and stock enhancement adopted in this paper. For example, swimming fish are more likely to sit within stock enhancement as, in the majority of situations, individual fish released into the wild are not able to be recaptured by the individual or group who released them.

This paper has been prepared by the Department of Fisheries and has been scrutinized by a focus group comprising a representative of the Department of Fisheries, the WA Fishing Industry Council, the Aquaculture Council of WA, RECFISHWEST and the Conservation Council of WA. This focus group will remain involved in the development of policy arising from this consultation process.

The information provided in this paper should not be accepted to be conclusive and stakeholders are encouraged to consider additional information from other sources in providing the basis for comment.

Your comments would be appreciated by **31 December 2002** and should be marked to the attention of **Aquaculture and Pearling Program – Senior Policy Officer**, and addressed to:

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PERTH WA 6000

EXECUTIVE SUMMARY

Enhancement of fish populations, both for private gain and public good, is becoming a significant policy issue for the Department of Fisheries. The practice itself is not new in the world. In Europe it has been happening for over a hundred years. What is not happening is the clear enunciation of policies for enhancement, including why it would be done at all. Neither are there monitoring processes in place to assess the success, or otherwise, of reseeding programs. The classic case of where this did occur after the event resulted in the closure of a reseeding program that had been in place for over 100 years!

The Department of Fisheries does not want to embark on what is 'new territory' in Western Australia without a policy framework to define what is to happen, why it is to happen, and what will happen if the project does or does not succeed.

This paper therefore attempts to do three things.

1. It sets in place accepted definitions of reseeding and stock enhancement within the general context of fisheries management in Western Australia.
2. It discusses the policy issues associated with reseeding grazing gastropods and bivalves into the natural environment.
3. It proposes a framework or process to be used by proponents and government in developing and assessing reseeding projects.

Although the principles will be largely the same for the reseeding of all species, this paper specifically addresses the reseeding of grazing gastropods and bivalves.

As the Department has already received applications for reseeding projects, and already has licensed a small number, it is important that the remaining policy, management and administrative issues be resolved so that a clear statement of policy can be released and a process developed or adopted for proponents of reseeding activities. These issues are addressed in the paper, but can be placed in the following broad categories.

- Ecological effects of reseeding.
- Resource sharing: balancing competing uses of the marine resources.
- Property rights and flow on effects, for example, who owns second stage (next generation) recruitment?
- Compliance – do we do it? If so, how much and who pays?
- What is the best administrative system to use to manage reseeding?
- What legislative issues need to be addressed to implement policy decisions?

This paper will commence a public consultation process, at the end of which policy guidelines for the assessment of reseeding proposals in Western Australia will be developed.

1. INTRODUCTION

1.1 The Fisheries Management Framework

The activity of enhancing natural populations of fish (or translocating fish where natural populations do not occur) is becoming recognised in Western Australia (WA) as a form of low intensity aquaculture that has the potential to support or augment wild populations of a species and increase the eventual yield.

Before discussing the various aspects of enhancement, however, it is important to set fishery enhancement within the context of fisheries management as it already exists within WA.

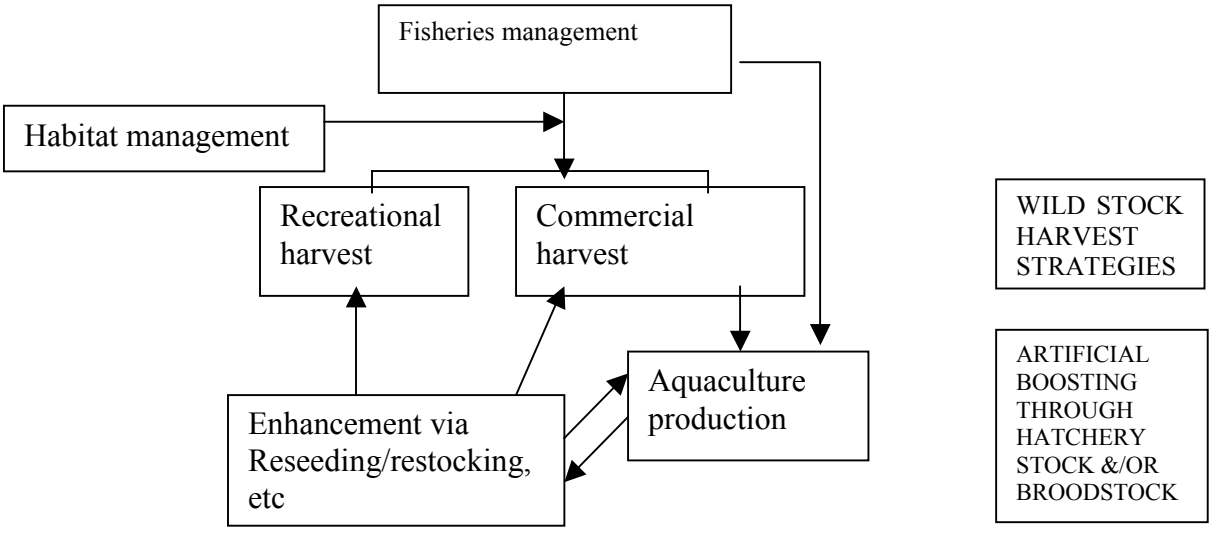
There is very little, if any, area of water off Western Australia that remains "in the commons", that is, open access without any form of management controls over fishing. Commercial fishing activities are managed over the extent of the coastline, either through management plans, fisheries Orders/notices and/or fishing licences. This is true to a lesser extent for recreational fishing. In this case, licences are required for rock lobster, abalone, netting, marron and inland angling. There are also a number of other management controls in place, for example, size and bag limits, and area restrictions.

In addition to these groups of extractive users of the fish resources, there are non-extractive interests – tourists, environmentalists, various downstream industries, as well as those people who derive pleasure from knowing a resource exists, even if they never see it. Aquaculture and pearling leases and licences are also in effect along the coastline, although most aquaculture facilities are on land. The notable exceptions to this are pearling and mussel leases and licences.

The following flow chart shows the enhancement strategies that are or may be employed

1. Managing harvest rates from the wildstock
2. Improving key habitats
3. Artificially boosting natural populations through reseeding with hatchery produced juveniles and/or translocation of broodstock.

Chart 1: Enhancement strategies employed to manage WA fisheries



The first two are proven management tools, the third is less certain – as a new management tool, it requires considerable research and development before gaining wider acceptance.

The main drivers for fishery enhancement are quality of fishing and economic return. These exist for both commercial and recreational fisheries. Commercial fishers want sustainable fisheries, quality product with minimal production costs and hence high returns. Recreational fishers want a quality fishing experience and hence need sustainable fisheries. With these usually come economic returns to local economies.

To date, enhancement of these marine fisheries has been mainly through fisheries management tools and in some cases, habitat modification/improvement. The practice of reseeding and translocating stock in inland recreational fisheries is not new in Western Australia (trout and marron for example), however, reseeding marine commercial fisheries is still in pioneer stages.

The recent interest in reseeding of marine fisheries brings an associated, but 'new', group into the picture – one that is likely to impact on all the above groups. It sits between the existing aquaculture and commercial fishing sectors. Product comes from aquaculture hatcheries but, once placed in the water for reseeding and harvest, becomes an additional commercial fishing enterprise. Consequently, fishery enhancement is arguably one of the biggest issues that will face fisheries management in the next ten years. With this activity come debates about resource sharing, scientific rigour, impact on genetics and biodiversity, how reseeding is integrated into ecologically sustainable development (ESD) processes, environmental impact, economic feasibility, and monitoring and evaluation strategies.

The *rapporteurs* of a symposium held to assess stock enhancement summarised well the "promises" and "clouds" of stock enhancement (Travis *et al* 1999). These apply equally to reseeding.

> "The appeal of stock enhancement rests in its simple premise and its bold promise. The premise is that we can raise large numbers of larvae or juveniles and, by releasing them successfully into the marine environment, compensate for the enormous natural mortality in these stages and thereby increase the stock size, in the late juvenile and early adult stages. The promise is that this intervention will compensate for the fishing mortality that created the problem in the first place. The premise appeals to our confidence in understanding natural populations processes and our optimism about managing nature successfully. The promise appeals to our reluctance to impose harsher and less popular conservation measures.
>
> Unfortunately, a host of unanswered questions about stock enhancement lurks behind the premise and clouds the promise. These questions extend into virtually every area of environmental biology, from population dynamics and genetics to ecosystem processes and resource economics."

1.2 Background

Over recent years, the Department of Fisheries has received an increasing number of enquiries from proponents interested in reseeding areas to enhance commercial fishing prospects in that area. To date, expressions of interest and applications have been received for trochus, giant clams, and tropical abalone in the north; temperate

abalone species on the west coast; and scallops on the south and mid west coasts. It is likely that sea cucumbers will shortly be added to this list.

In the absence of a specific policy for assessing such applications, proponents have made applications for aquaculture licences to secure areas of coastal water. Applications are assessed on a case-by-case basis using the process established through Ministerial Policy Guideline Number 8 (Fisheries Dept of WA, 1997).

Interest has also been shown in enhancing fisheries for finfish, such as snapper in Shark Bay; however, this paper does not attempt to address the wider issues of reseeding other species or of stock enhancement. A discussion paper on these wider issues is being developed separately.

This paper attempts to address the policy issues surrounding the management of reseeding grazing gastropods and bivalves into the marine environment and to provide a possible way forward for the licensing and management of reseeded fisheries.

1.3 What is Reseeding?

Internationally, attempting to enhance natural populations of fish is not a new activity, although it is not until fairly recently that scientists have moved to define the various enhancement activities, understand the processes involved and attempted to evaluate them.

The international definitions, which will be adopted as the basis for discussion in this paper recognise that when natural fish populations are enhanced, the result is either a private gain or creation of a public good. These two results have led, internationally, to the definition of two activities - 'ranching' (or 'reseeding') and stock enhancement. (Bannister (1991) and cited and reaffirmed in Howell (1998)):

> "*Ranching: Identifiable*[1] *stock released with the intention of being harvested by the releasing agency*. [We will call this 'reseeding']
>
> This implies a cost-benefit analysis based on comparing the harvested value with the cost of production, release and harvesting.
>
> *Enhancement: Stock released for the public good without the intention of benefiting an exclusive user group.*
>
> This would include:
>
> (1) compensation for depletion of a natural resource (restocking);
>
> (2) compensation for loss of habitat (augmentation);
>
> (3) genuine addition of new stock (e.g. stocking artificial reefs) (addition)."

This paper will concentrate on reseeding, that is, ranching, and more specifically, the reseeding of grazing gastropods and bivalves. In using the term 'reseeding', it is recognised that the 'seed' to be reseeded is not necessarily small or young (which may be implied by the use of this term), it may be that juveniles or older animals are used.

Further, the term 'reseed' will include seeding areas with broodstock and/or juveniles where the species does not already occur. Such projects would be allowed subject to

[1] Stock released may not always be identifiable and it will not always be required in Western Australia. See discussion within this paper.

translocation protocols being met, in addition to other requirements as established through this policy process.

1.4 Why Reseed the Natural Environment?

From a search of the literature covering international experience of reseeding, the immediate reaction would have to be that reseeding should not be undertaken. Too little is known of the impacts of reseeding on biodiversity and ecological impacts, its relationship with natural population variability, and the social and economic implications. Yet, the questions need to be asked and a policy framework developed because there will always be a case where reseeding will be justified and feasible or where a political decision is made to proceed anyway.

Given this, to answer the broad question on why reseed, a few more questions need consideration.

- Why is the fishery performing the way it is?

Where reseeding is proposed within an existing fishery, the first question has to be "why is there a problem that needs fixing?". There may be a number of reasons why a reef or seabed has been denuded or has a reduced population of a particular species. Gastropods, by nature, are usually chaotic/unpredictable in their recruitment (Molony, pers comm.).

Fishery performance may be related to natural variability in recruitment or population age structure at a particular site. There may have been a natural environmental event, such as a significant change in water temperature, an influx of predators, a cyclone or a serious disease. Alternatively, there may be man-made impacts - changes to the marine environment that have affected natural populations, such as dredging, coastal development, or pollution. There may have been overfishing of the stock by commercial and/or recreational fishers. Where this is purported to be the case, it is important to identify whether the low performance of the fishery is due to naturally low populations of fish, too little fishing effort (the problem is perceived and there hasn't been enough fishing to prove it really is a problem) or too much fishing effort (found them and fished heavily).

- Is reseeding a desirable fishery management tool?

In the majority of cases, the answer will be 'no'. At the most, reseeding should be seen as a supplementary management tool. In the Australian and Western Australian context, it should never be seen as a substitute for established fisheries management methods.

Caution needs to be exercised in using reseeding generally to replenish stocks that have been overfished commercially or recreationally. It cannot restore overfished stocks beyond the capacity of the system and it will not work without other more established management measures, such as effort controls. Further, reseeded stocks could replace wild stocks in the ecosystem by taking up areas that would otherwise be taken by recruited wild stocks. The end result could still be a more productive fishery, but at the expense of the wild stock, biodiversity, and trophic impacts.

Consequently, reseeding should not be considered on a par with other fisheries management tools as a method of correcting an overfished fishery. Where a decision is made to use reseeding for this purpose, it will be necessary to put in place stringent management conditions to ensure that the reseeded stock is protected and that the

enhanced fishery is not overfished. This is also a requirement set down by the Department of Environmental Protection.

Two further questions also need to be asked. Firstly, prior to reseeding reefs/seabeds where a species does not occur naturally, it is important to establish why the species is not there, as this could be critical to the success of reseeding operations. Not only may it cause the reseeding to fail, but also it will impact on the existing ecosystem. Secondly, is the reseeding one-off or recurring – is it addressing an immediate need or establishing a plantation? The answer to these questions will greatly sway whether reseeding should be entertained as a management option as the implications differ.

However, having said this, there are circumstances where reseeding would be acceptable. A case can be made for the trochus fishery in the Kimberley region and also for reseeding of scallop beds.

On some reefs in the Kimberley, Western Australia trochus either do not occur or were over fished in the past and have not recovered. Establishing or re-establishing trochus on these reefs could allow the particular communities to gain additional income for essential living. In this circumstance, there may be social and economic benefits to the local aboriginal communities and, depending on the significance of the reef system, the impact on other users and other components of the ecosystem may be minimal or non-existent.

Some species of scallops have been successfully reseeded elsewhere (Dredge, *et al,* in draft) and a licence recently issued for this purpose off Western Australia should enable full evaluation of the activity and hence increase our understanding of reseeding of this species.

Where a natural environmental change or a man-made change to the environment has affected stock levels, it may also be appropriate to reseed an area. Applications may range from smoothing out natural fluctuations in recruitment of scallops and prawns to one-off reseeding to compensate for the impact of events, such as an oil spill. Where environmental changes are involved, the likelihood of reoccurrence of the original disturbance would need to be taken into account prior to reseeding.

- Could the initial problem by resolved through habitat modification?

It may be the case that natural recovery of fisheries after overfishing is hampered by habitat changes that occur as a result of that overfishing. For example, when an abalone reef is overfished, seaweed can grow over the reefs and take over the abalone habitat. In such a case, there is no habitat left where abalone can regenerate. It may be feasible to 'weed' the reef and hence restore the habitat to one where abalone can regenerate naturally.

If the target species is density dependent, habitat structure may be a limiting factor in the harvestable population level. It may be possible to modify or enhance this structure to the benefit of the population and hence remove the need to reseed.

- Is there information on the natural stocking densities and survival rates of species for the areas being reseeded?

For most part, the answer to this question is 'no', although there are some preliminary estimates for trochus. How is carrying capacity calculated and measured? It is very difficult to determine the limits to a system, that is, how many units of hatchery-reared fish can the system accommodate? This would vary from year to year according to environmental fluctuations. Even if this could be calculated, the current

carrying capacity of the system may be reduced relative to historic levels due to habitat modifications. Carrying capacity will also be influenced by the size or stage of fish to be released.

There is also a lack of information on recruitment and other variables – it may be that reseeding could be irrelevant in terms of quantities of reseeded recruits compared with natural recruitment.

Survival rates and the likelihood of recruitment bottlenecks (for example, limited available habitat) also need to be known, as these are integral in assessing economic viability.

- What about seeding of artificial habitats?

If the structure has been in place for enough time for marine life to attach itself or aggregate around the artificial structure, then the issues to be faced are not much different from natural marine environments in terms of reseeding. If however, the reseeding proposal includes the actual modification of the natural environment, there are a number of direct and indirect environmental impacts to consider, such as change in water flow and impact on existing marine life. Little research has been done to evaluate the effectiveness of altering habitat to facilitate reseeding and it is difficult to replicate structures so that effects can be isolated from natural changes that would have occurred anyway.

Such proposals would be considered, subject to the requirements of fisheries, environment and other associated legislation.

- Private ownership/public good

A number of fisheries management and policy issues need to be addressed in relation to reseeding activities including discerning ownership of stock, access rights to the area and the need for large areas of water and in some cases, reef structure to be allocated for these activities.

If reseeding is considered to be the best management option to enhance a particular fishery, then there has to be some incentive for a proponent to invest in hatchery production and to reseed an area. In the majority of cases, the proponent would request exclusive access to the reseeded area and the stock within that area. Effectively, the issue of private 'ownership' (for whatever length of time) over what may currently be available for the public good; or if not public, then available to a wider group of people than would be the case if reseeding proceeds.

In some cases this is not a problem, for example where the proponent is a collective of all commercial licence holders and it is an area of little interest to the wider community, including recreational fishers. Some of the trochus, scallop and abalone sites could fall into this category. However, where there are other user groups with an interest in the area being proposed for reseeding, exclusive access may not be an easy option. Closure of an area or fishery for reseeding has social, economic and political costs, as does any fishery management decision, and these costs need to be factored into the decision-making process.

Where the decision is made not to close the area to all user groups, there is the need to differentiate between seeded and natural stock. Unless there are obvious morphological differences between seeded and natural stock, all animals to be reseeded must be marked in some way, chemically or otherwise. It will not be

possible in the case of some species to tag in a way that is visible to the naked eye, but for scientific and compliance reasons, reseeded individuals must be identifiable.

Although small, reseeded spat cannot be marked in a way that identifies the animal to the naked eye as different to naturally occurring spat, this may not be the case as the animal matures. Reseeded trochus has been found to be morphologically different to naturally occurring animals (Purcell, in review). Dredge, *et al* (in draft) also cites research showing characteristic pigment flares and checks of the shells of adult scallops due to capture and sorting. It is therefore possible that hatchery-reared juvenile scallops will acquire substantial check marks during transportation and reseeding. Further, trials show hatchery-reared scallops have very characteristic colouring and growth patterns readily distinguishable from wild scallops. Whether this is also the case for abalone is not yet known.

Complications could also arise if reseeded stock migrates outside the licensed lease area. Questions also arise over who 'owns' the next generation of stock, as it is likely in most cases that reseeded stock will breed with naturally occurring stock – which recruitment is from seeded stock and which is from naturally occurring stock? Such issues need careful consideration and clear explicit rulings on these matters need to be made prior to licensing reseeding projects. Output based solutions may address some of these issues, however, they present their own problems and will need to be considered on a fishery-by-fishery basis.

- Will accepting reseeding as a valid management tool send a message that it is acceptable to fish down fisheries as they can be restored through reseeded stock?

Acceptance of reseeding as a valid management tool would need to be accompanied by the strong message that reseeding is not the answer to overfishing. It will not be viable in all fisheries or areas of fisheries and is likely to be the exception rather than the rule. Sound fisheries management practices need to be in force in all commercial and recreational fisheries and if they are not, reseeding will not solve the problem of low stock levels. Reseeded stock would fall to the same problems as natural stock and potential economic benefit would be lost.

1.4 Advantages and Disadvantages of Reseeding Activities

Having outlined circumstances where reseeding may or may not be desirable, there are some practical advantages and disadvantages of reseeding activities.

1.4.1 Advantages

- There is no, or minimal, infrastructure at site of reseeding.
- Seed for most species would come from the controlled environment of a hatchery.
- Initial stocking densities could be at or below naturally occurring densities (where this level is known), or at conservative levels where stocking densities are not known, thereby minimising the impact on the environment.
- In some cases, such as trochus reseeding, the activity may allow traditional fishing to be re-established in areas that have previously been depleted of stock, providing a source of income.
- Smoothing of natural fluctuations may be possible with species such as scallops.

- In most cases, no artificial feeding is required.

1.4.2 Disadvantages

- There are very few reliable hatcheries to produce spat and if spat is not available, proponents need to gain approval to take juvenile stock from the wild.
- The success or otherwise of reseeding techniques is largely untested for many species, locations and conditions and therefore the survival rates of juveniles is unknown and difficult to determine.
- The economic viability of reseeding is unclear for the majority of species (internationally, very few cost benefit analyses have been conducted).
- The environmental impact is not known or well documented, however the introduction of hatchery stock into the marine environment will have some impact.
- There are difficulties in determining 'ownership' of stock and differentiating between wild and hatchery produced stock.
- Placement of reseeded stock into wild fisheries may impact on the existing wild stock, in terms of competition, genetic diversity and trophic effects on ecology.
- It may require closing the area to other user groups, which incurs a social and economic cost.

2 RESEARCH

A snapshot of some recent research on these major species being reseeded, and proposed for reseeding, is at Appendix 1. A search of existing literature reveals a number of gaps, the largest of which are in the areas of scientific prediction and economic and social impacts.

The success or otherwise of any enhancement will be linked to what is happening in natural recruitment of the species in question. It would be extremely difficult to successfully enhance a species in poor years of recruitment as sufficient spat or juveniles may not be available. What is needed is a predictive system that warns when the fishery/area is going to be productive or experience poor recruitment so that those involved can be ready for the poor years.

Even with a predictive system to allow placement of stock at the most effective times, there must be understanding of what caused the natural fluctuations because whatever caused these fluctuations may also impact on the survival of reseeded stock.

Bannister (1991) makes the following observations on issues where questions still need to be answered.

- The importance of behaviour of hatchery stock following release and the impact of the additional stock on the food chain (as predators, prey and competitors).
- Ecological studies into carrying capacities would provide valuable information for management of both aquaculture and wild stock fisheries. (However, carrying capacities vary from year to year, which adds complexity to the issue).

- There is a need to improve the definition of time and place for releasing stock into wild, and in evaluating which life history stage is best for ecological and economic reasons.
- Successful application of enhancement techniques (scallop, among others) raises important contingent questions about management, gene pools and ownership. For example, the aggregation of predators, including fishers, on enhanced stocks, may be to the detriment of wild fisheries in mixing areas.

Aquaculture (and hence reseeding) involves innovation, a high degree of uncertainty and many unasked and unanswered questions. Hallenstvedt (1999) suggests that for enhancement programs the traditional role of research and advice for management of wild stocks changes to the management of economic development. Research has barely scratched the surface of social and economic issues associated with reseeding and/or stock enhancement.

3. LEGISLATIVE BASIS FOR MANAGEMENT OF RESEEDING ACTIVITIES

The objects of the *Fish Resources Management Act 1994* (FRMA) are to conserve, develop and share the fish resources of the State for the benefit of present and future generations (section 3). These include, among other things, the conservation of fish and the environment, sustainable exploitation, development of fisheries and aquaculture, allocation between user groups, and optimising benefits from the various users.

The legislation provides a number of tools for meeting these objects, the most common of these being licensing and regulation of the various fishing and aquaculture activities. Given competing uses often occur within the same site, resource sharing issues constantly need to be addressed. Reseeding is no different in this respect.

For example, where a reseeding site(s) is proposed within the bounds of an existing commercial fishery, there are two policy options: require all applicants to be holders of commercial licences for the fishery concerned or require the applicant to negotiate access with the commercial licence holders. An aquaculture lease would not be issued over that area of water while it was still part of a commercial fishery for the species being proposed. Given it is probable that access to commercial fisheries within which reseeding is likely to occur would already been allocated, if the second policy option was chosen, the area for reseeding would need to be excised from the area of the managed commercial fishery. This may or may not require compensation to the commercial licence holders.

Recreational fishers may also have access to a proposed reseeding site, although not under a legislated management plan. Any consideration to close an area for the purpose of reseeding must still consider the impact on recreational fishing activities. These resource allocation issues will need to be addressed on a case-by-case basis.

4. DEVELOPING AND ASSESSING A RESEEDING PROPOSAL

There is a lot of evidence to suggest that reseeding is not likely to be successful and there are a lot of impediments to its success in most cases. There may be projects that

would be successful in reseeding a particular species or area, but the externalities may be such that the proposal is not approved. However, there will be circumstances when it is justified, feasible and desirable to reseed an area or a particular species.

This being the case, there are important issues that are crucial to both the application process and the actual reseeding process. The remainder of the paper will address these issues. In short they are:

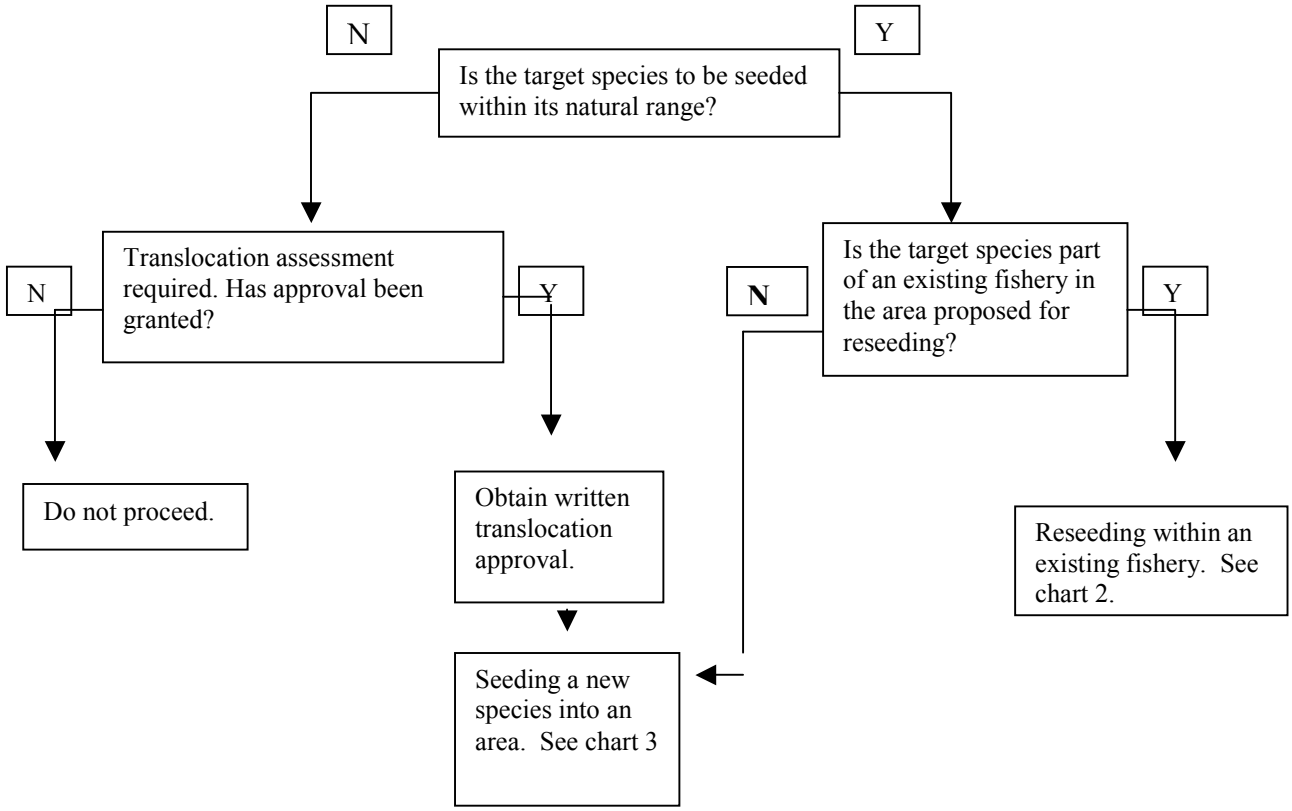
- The need to establish management objectives and performance targets;
- Assessment and remediation of the environmental impacts of the project;
- The need for a thorough cost benefit analysis;
- How applications would be assessed and projects licensed;
- The need for a pilot project;
- Monitoring and evaluation of both pilot and long term reseeding projects; and
- The role of compliance.

To assist proponents of reseeding projects develop their applications and fisheries managers assess those applications, two decision trees have been proposed (pp 21-22). The first (Chart 2) provides an assessment process where reseeding occurs within an existing fishery. The second (Chart 3) provides an assessment process where the proposal is for seeding a new species into an area. These charts are derived from one developed by a number of Western Australian fisheries research scientists (Molony *et al,* in draft) to establish a scientific basis for stock enhancement.

The steps and questions posed would be used by managers to assess any reseeding application and hence should be given serious consideration by applicants and used as the basis of developing any reseeding proposal.

To assist in deciding which chart to follow, a few basic questions can be posed. These are set out in Chart 4, following.

Chart 4: Overview assessment for reseeding projects.



5. MANAGEMENT OBJECTIVES

5.1 Fishery Management Objectives

A reseeding project may or may not be located within the area of an existing commercial or recreational fishery. Consideration of a reseeding application, therefore, must take into account any existing fishery and the management objectives that form the basis of management regimes in place for those fisheries.

Marine ranching cannot stand alone but must be part of an integrated management plan that encompasses technology, biology, genetics, ecology, socio-economics and politics (Bartley 1999).

5.2 Management Objectives of the Reseeding Program

Any proposal to reseed a specific area needs to be based on clear, explicit objectives.

These management objectives must be stated both in relation to the management objectives of the fishery or stock involved (which are sometimes not stated), and to the limitations of the system (generally unknown). This also allows the establishment of objectives that may not be directly related to the fishery (for example, flow-on beneficiaries of recreational fisheries, such as accommodation providers in regional areas). Setting objectives prior to the commencement of any reseeding activities allows those objectives to be assessed and reviewed once reseeding is underway.

Clear objectives also provide direction for management of the reseeded area or fishery. For example, is the reseeding aimed at enhancing an already productive reef? Is the reef denuded because it has been overfished? Was the reef always barren and the project will test whether a population could be viable on that reef?

The success of enhancement depends to some extent on these objectives. For example, is the project merely seeking to cause an increment of value over costs, will it result in a new addition of adult stock that needs to be sustained on an ongoing basis or will the addition of stock be a self-sustaining addition to recruitment in which case, what are the carrying capacity limits? Is it a one-off mitigation event or an ongoing venture? (Adapted from Bannister 1991).

6. STOCKING STRATEGY

A stocking strategy must also be considered and developed in regard to the species and the environment. This should consider the species to be released, the environment into which stock will be released, the number and size of fish to be released and the timing of these releases in relation to natural cycles or weather conditions.

Travis *et al* (1999) report “successful stock enhancement is possible only for species with density-independent mortality in the larval or juvenile stage or, for species with density-dependent mortality in those stages, when the natural densities of larvae or juveniles are very low”. Further, sufficient habitat for the age/size to be released must be available in the release area. The suitability of this environment will be a strong success factor for the project.

Having considered the environmental/ecological factors, the strategy should also account for the economic costs and benefits of different release points and times.

7. ENVIRONMENTAL IMPACTS

Any enhancement, successful or not, will have impact. The impact is that something will always change in some level of the ecosystem, whether it be food source, predation, competition, or some other interaction.

Visibilities of this change, or lack thereof, may be proffered as an argument in support of re-seeding, however, seeing change is not the only reason for supporting or objecting to reseeding activities - some people just want to know that some species are out there and if reseeding affects those species, there will be concern. Neither is it a valid argument to say that reseeding would return the ecosystem to its former balance, because the denuded reef may now house some other organism that has value to someone and to re-seed with abalone, say, may alter the new ecosystem. Further to this argument, in many systems, there is no information as to what was the 'natural balance'.

The environmental impacts of reseeding gastropods are addressed more fully in the document *Reseeding of Grazing Gastropods and Bivalves into the Marine Environment – Potential Environmental Impacts and Management Control*, (internal policy paper, unpublished). Appendix 2 provides a summary from this paper of the potential environmental impacts of reseeding marine habitats with mollusc species that would require specific assessment and monitoring and the policies now in place to deal with these potential impacts.

8. COST BENEFIT ANALYSIS (CBA)

Hallenstvedt (1999) rightly points out that it is hard to predict future benefits of something when it is at an early stage of development. However, even a basic cost benefit analysis is better than no economic assessment. Where a cost or benefit cannot be quantified, it should be described qualitatively. For example, the loss of public amenity may not be fully quantifiable, neither may some of the impacts identified through the Ecologically Sustainable Development (ESD) processes.

Whatever the complexity of the CBA, it needs to pay particular attention to the stated objective of the project and should distinguish carefully between options to optimise benefit over cost and options to maximise benefit at infinite cost (Bannister 1991).

There are a number of factors that makes cost benefit analysis for reseeding a difficult exercise.

- Transformation of scientific knowledge into economic enterprises based on living marine resources involves a high degree of uncertainty and has a long time frame. During that time, it is likely that costs and benefits will change, not only in size but also in type.
- Aquaculture is a process of innovation. Knowledge will grow, technology change and there will be breakthroughs that will provide basis for evaluation of future benefits, but at this stage they are not known and hence cannot be quantified.
- At the introductory stage of reseeding, the cost of enforcing private property rights might easily exceed benefits. If the government decides to carry this cost, who pays for it?

- Is reseeding a one-off exercise? Is it a mitigating tool (against years of poor recruitment/chaotic event such as a cyclone) or sustained production? The costs of each objective differ.
- What about predicting other unknowns, such as, climate change, future coastal developments, etc and the flow-on effects?
- Many social costs are difficult to assess. If the government decides that reseeding is a desirable management tool, then closure of the area is one of the costs and needs to be assessed as one in any economic evaluation of the proposal. Some of these costs will be quantifiable, some not.

Laurec (1999) provides some insights into the implications of allocating costs and benefits. He suggests that estimating overall costs and benefits, even including upstream costs and downstream benefits, is not enough for decision makers as they must choose between the diverging interests of those who cover the costs and those who enjoy the benefits. In addition, they have to anticipate changes because it is a dynamic system. This affects not only technical and economic parameters, but also priorities as perceived by public opinions, such as environmental considerations.

9. MPG 8

As a result of considerable concern expressed by the community regarding the potential impact of aquaculture, particularly in high and multi-use areas, a licence assessment process (Ministerial Policy Guideline No. 8) was published in 1997. This process provides an opportunity for public input into the licence assessment process for marine sites as well as providing a greater assurance to proponents on the timeframes to apply.

All applications for reseeding will be assessed according to the process established through this Ministerial Policy Guideline (*Assessment of applications for authorisations for Aquaculture and Pearling in coastal waters of Western Australia)*.

Given the potential impacts of reseeding ecologically, economically, environmentally, and socially, it is proposed to establish a small committee comprising key stakeholders to assess each application and make recommendations to the Executive Director on the grant of a licence. This step is supported and recommended by Cross (2000) and there is precedent within the Department of Fisheries with the Developing Fisheries Assessment Committee (Fisheries WA 1999).

10. LICENSING OF SUCCESSFUL PROPONENTS

10.1 What licence would be issued?

10.1.1 Short term

Where reseeding does not occur within a commercial fishery, the proponent would be required to hold an aquaculture licence. These licences are granted where the activities being carried out are unlikely to adversely affect other fish or the aquatic environment, are in the better interests of the aquaculture industry, and have been approved by other relevant authorities.

Where reseeding is within an existing commercial fishery, access for reseeding would be either through commercial fishing or aquaculture entitlements, or some combination of both. Existing successful applicants hold both.

An example of existing licence conditions for reseeding of abalone are at Appendix 3 as an indication of the types of conditions that may be applied to a wider range of reseeding licences.

10.1.2 Long term

In the longer term, it may be more efficient to change the legislation to create a specific licence for reseeding that covers all stages of the activity from sourcing spat, placement, grow out and harvest. The existence of one licence would not remove the necessity to hold appropriate access entitlements for any associated commercial fishery. How these processes are interlinked will need to be given careful consideration and full consultation/negotiation.

10.2 Term of licence

An aquaculture licence is renewed on an annual basis, subject to the licensee remaining a fit-and-proper person. However, if all conditions were fulfilled there would be no reason to revoke the licence and it would continue within the life of the current legislation. An advantage of ongoing renewal is that it may take years for animals to grow into harvestable size. However there are also disadvantages to issuing reseeding licences on this basis, given the intention to monitor the success of the project against predetermined objectives.

Consequentially, aquaculture licences issued for reseeding projects will be issued in two stages. Firstly a licence to undertake a trial reseeding project will be issued. The trial period would depend on the lifecycle of the species being reseeded, but would basically cover the time required for grow-out and harvest. If the project is assessed against the objectives for the project as being successful, then a further licence would be issued to allow the reseeding project to be established on a 'permanent' basis.

Consultation with other user groups, through the process set out in MPG 8, should be in the framework of these two stages of development.

11. MONITORING SUCCESS

11.1 What is success and can it be measured?

The long-term viability of reseeding as an enhancement option rests largely on the ability to define and measure 'success' and economic viability. These are huge issues and they are tied together.

Firstly, 'success' needs to be defined. The definition of success will depend on why the project is being undertaken, that is, whether it meets the predetermined objectives. It will be "a complex function of ecological, economic, philanthropic, political, sociological and perhaps even religious factors" (Hilborn in Travis *et al* 1999).

Laurec (1999) makes the following observations on the need to define success of enhancement projects.

- Of all enhancement in the world there are few, if any, comprehensive analyses of an enhancement program covering ecological, economic and social aspects.
- Persistent reasons (and sometimes increasing appeal because of stock depletion) make stock enhancement attractive outside the scientific community. Too many users and decision makers believe that through stock enhancement they can avoid painful decisions related to habitat or wild stock management.
- Making the right choice when launching a programme is all the more essential as it is very difficult to put an end to an existing one.

Secondly, how is 'success' measured? It is extremely difficult to measure the success of a reseeding project in most cases. This has been proven time and time again throughout the world. In many cases, the decision has been made to reseed regardless of its success or economic viability. In others, reseeding was taken as given and evaluation not undertaken. This was the case in Norway where enhancement of North Sea cod had been underway for over a hundred years. During the 1970s, 80s and 90s, a reseeding research program was conducted to assess whether enhancement of North Sea cod was actually effective. Research continues, however, survival rates in some areas were not encouraging. For example, Svåsand, 1998, reported that of 18 million larvae released into a small fjord, less than 120 cod were alive after one year.

This Norwegian case was eventually assessed and judged in terms of economic success, however, as mentioned earlier, the objectives of the reseeding program may not be economic efficiency. Reseeding programs have been undertaken in Japan (and a number of other Asian nations) for a number of years and the view to these programs has been a holistic one – they include cultural, social, linked activities, education and sea development in their sea-based communities. Programs viewed in this context allow 'uneconomic' reseeding activities to be supported.

Regardless of the objectives of the reseeding project, any reseeding program should be accompanied by a rigorous scientific evaluation that involves following the fate of introduced fish. Stocked fish should be monitored throughout their life in the fishery, from immediately after stocking until stocked fish can no longer be detected. This evaluation will provide valuable information to any re-evaluation of the reseeding project, if required. For example, if nearly all stocked fish survived to fishable size or reproductive size/age, then an evaluation over this time period (i.e. until all reseeded stock was recruited to the fishery) would provide information about the competency of hatchery-reared fish and their interaction with wild fish. No reseeding project should be considered without an adequate scientific assessment of the effectiveness of this tool. (Molony *et al*, in draft).

Having said this, given reseeding has been defined as releasing stock with the intention of harvesting by the releasing agent; the focus of success should not be aimed totally at biological measures (however, there should still be regard for the quality of the ecosystem into which stock is released). Economics is now a driving force. Key variables will be the cost of producing juveniles, the survival rate and the harvest value (Hallenstvedt, 1999).

Economic viability should also take into account the cost of establishing success indicators and measuring these indicators throughout the grow out period and subsequent fishing years. These costs are much higher in marine environments where the reseeded area is not a closed system (compared to dams, for example). Adding to

this are the costs of not fishing an area during grow out of the reseeded stock. In most cases this will be necessary as spat for gastropods and molluscs can not be marked in a way that will allow visible identification while the animal is in situ prior to harvest (Molony *et al*, in draft).

11.2 The need for a pilot project

The important first question to answer may not be how to measure success of a project in the long term, but whether reseeding should be done in the first place and if it is, how to go about putting structures in place to make sure it is done right, and if not, why it went wrong.

To this end, it is essential to put in place a pilot project before the start of a long-term reseeding project. This pilot project, to be licensed only for the term of the pilot, should have clear objectives and have in place steps to monitor the progress, 'success' or 'failure' of the pilot project, however these terms are defined. Pilot projects should only be licensed after a commitment from the proponent to complete the trial – a proponent should not be permitted to stock an area and then withdraw from the process.

Monitoring could be based around targets that are established prior to commencement of the project. These may include percentage increases in fishable biomass; percentage increases in reproductive biomass; target levels of catch per unit effort, etc. At this stage it should also be determined how to best evaluate the effectiveness of reseeding in relation to these targets. (Molony *et al*, in draft)

The pilot project allows a full evaluation of the techniques (including tagging/marking) at a useful scale, but small enough so that any negative effects (for example, displacement of wild stock or other species) will occur on a small scale. Further, if the project does not work at this level, then minimal loss of investments will occur. (Molony *et al*, in draft)

It will be important if a pilot is not successful, to recognise why this has been the case. For example, it is extremely difficult to manage enhancement in poor years of recruitment due to the timeframe for assessing recruitment strength and producing suitable spat. A similar project at a different time may be more successful.

It is acknowledged that there are risks associated with conducting trials on a commercial level; however, the risks of not doing so appear greater. Ways of minimising risks will need to be considered in consultation with proponents.

11.3 Impact on the stock of the species being reseeded

The significance of the impact of the reseeded stock will depend on the objectives of the project. Was the intention to re-establish a population in a denuded area? Was it to enhance an existing population? Depending on the objectives, monitoring needs to answer questions such as the following. Has the program resulted in a one-off increase in population and hence catches? Has it contributed to real sustainable growth in the population? Has the introduction of reseeded stock had a positive or negative effect on the population of wild stock – has there been augmentation or habitat replacement, is there competition for food, has the genetic diversity of the stock been significantly altered, etc?

11.4 Flow-on effects

11.4.1 Ecosystem effects

Will there be flow-on effects to the area (such as a reduction in the numbers of other predatory species of fishes in the area that anglers target)? Will water quality be reduced, particularly in a freshwater reservoir (a major issue with water supply authorities in some States)?

11.4.2 Intergenerational effects

If the program actually did increase the base level stock, there is still no way to identify the progeny of wild and reseeded animals. This being the case, how is ownership of this integrated stock defined?

12. COMPLIANCE

Ideally, all reseeded stock should be visibly tagged to enable differentiation of reseeded and natural stock. However, unless morphological differences exist between wild and hatchery-reared stock, for most grazing gastropods and bivalves this will not be feasible as spat would most likely be too small to put in visible tags. The implication is therefore that within an aquaculture licensed area, it may not be possible to identify reseeded stock from natural stock by eye. There are, of course, chemical and genetic tags that could be used to identify reseeded stock through scientific examination.

This raises a number of compliance issues that need to be addressed.

- The granting of exclusive access creates a private right and with it should come an obligation to protect the resources within that area. Therefore, the general Departmental policy would be that any poaching of stock would be theft of private property. However, the specific treatment of offences would be dependent on circumstances and would need to be addressed on a case-by-case basis.
- Compliance within Aboriginal fisheries will be largely based on co-management of the fishery and agreement with the rules in place for management. Distance, cost and social issues (including ownership overlaps, and native title) could prevent effective compliance.
- Quota managed fisheries, such as abalone, present a wider problem in terms of quota busting, and tracking which fish come from the natural fishery and which from the reseeded fishery. Strategies to address this must be put in place prior to aquaculture product reaching approved size. This issue may be further complicated by decisions made on the legal size for reseeded product. In the case of marron, the legal size for aquaculture stock is smaller than for wild stock. If this precedent is adopted for fisheries where commercial fisheries exist on wild stock, the compliance and associated management issues are magnified considerably.

Given these issues, a compliance risk assessment and compliance plan should be developed up front as part of any assessment and approval process for licensing of reseeding activities. This risk assessment and compliance plan should be developed

by proponents in conjunction with compliance officers of the Department of Fisheries, as compliance requirements impact not only on the activity in question, but on other compliance projects. Both private and government compliance strategies need to be developed and clear statements made as to who pays for each component.

Chart 2: Framework for Assessing Potential Reseeding Projects in Existing Fisheries

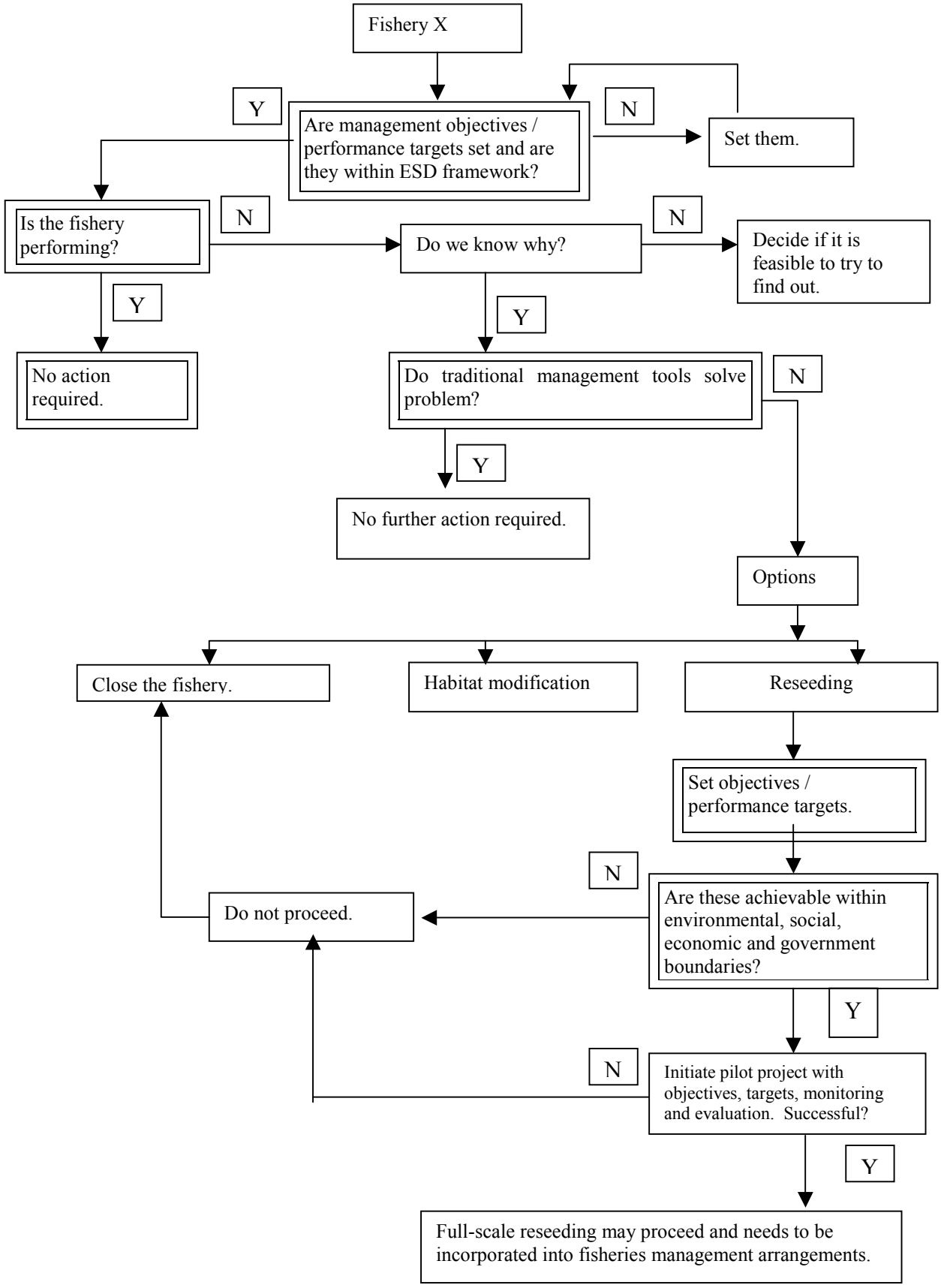
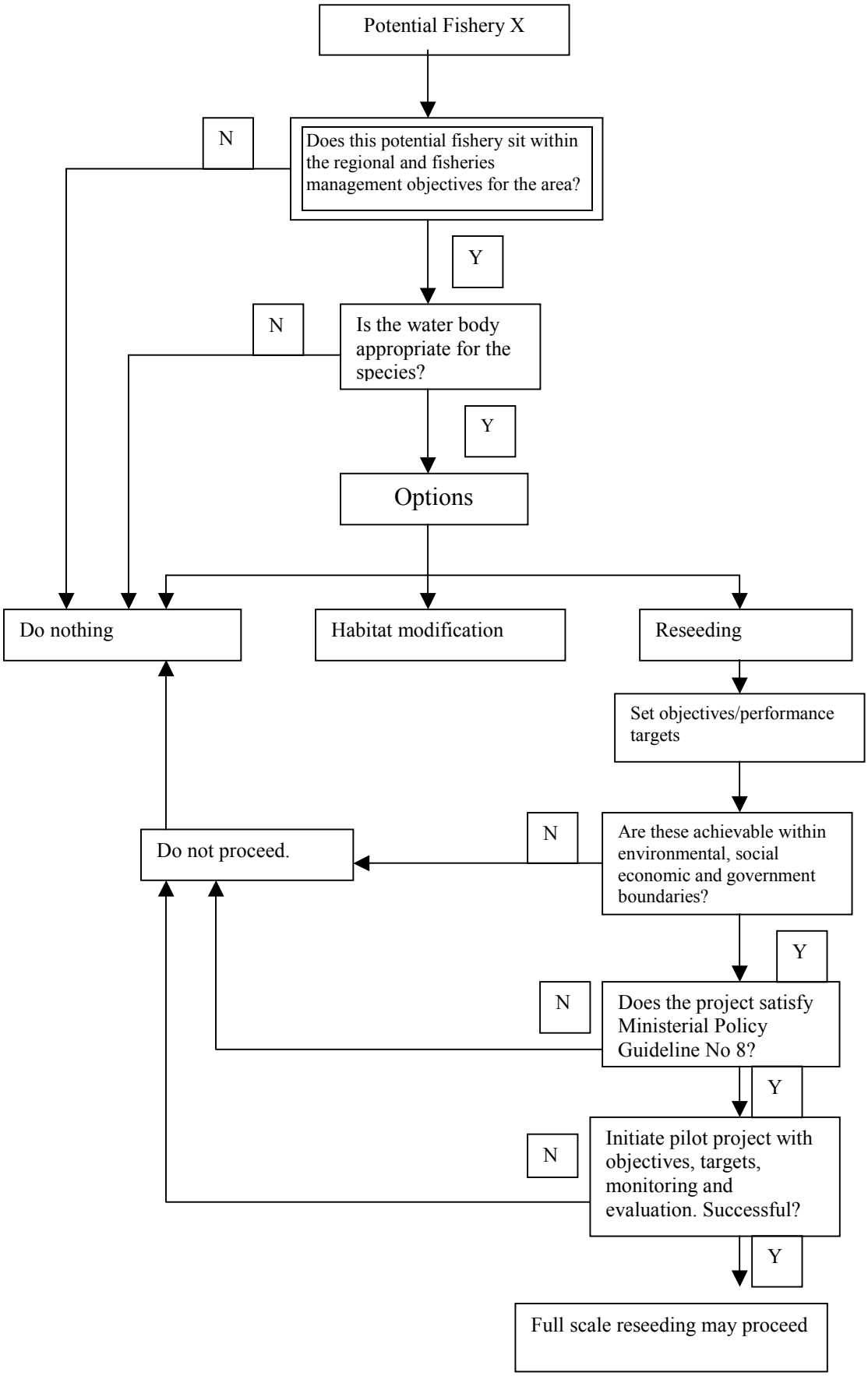


Chart 3: Conceptual Framework for Assessing Potential Reseeding Projects that lie outside an existing commercial fishery for that species



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APPENDIX 1

Appendix 1: Research

Trochus

The following information draws from a funding application to the Australian Centre for International Agricultural Research (ACIAR) for a project entitled *Integration of broodstock replenishment with community-based management to restore trochus fisheries*, (Dept of Fisheries).

Research on the effectiveness of strategies for restocking trochus has been funded by ACIAR since 1993. One of the main outcomes of the latest ACIAR trochus reseeding research project, completed in July 2001, indicated that it is feasible to use broodstock seeding as a tool to re-establish stocks on depleted sites or suitable sites where trochus are absent.

Experiments carried out under this project in Vanuatu were highly successful, with a small number of broodstock rapidly enhancing local recruitment of juvenile trochus. There was both a high degree of recruitment at broodstock sites as well as the appearance of juveniles at control sites a few kilometres away. However, in similar trials in Western Australia (Dampier Peninsula and Sunday Island, both in the Kimberley), broodstock seeding did not appear to have resulted in subsequent recruitment of juveniles. Contributing factors could include poor recruitment during 1999/2000 wet season, huge tidal range, unsuitable sites, and water current direction not conducive to self-recruitment. It may also have been attributable to the harsh Kimberley environment, which could result in much slower spawning that takes a number of years. The success in Vanuatu showed the enhancement method can work, but that it may be reef dependent or sporadic.

Based on the success of juvenile seeding in King Sound and broodstock seeding in Vanuatu, ATSIC and the Kimberley Aquaculture Aboriginal Corporation (KAAC) decided use the multi-species hatchery (MSH) in Broome to produce juvenile trochus to enhance its depleted reefs. KAAC intends to reseed trochus depleted reefs in 17 aquaculture farm licensed sites across the Kimberley with the view to ensuring sustainable trochus enhancement in all suitable reef sites across the Kimberley. Aquaculture licences have been issued for these and other sites in the area.

Abalone

Lapota *et al.* (2000) note a number of factors that affect the successful growth of reseeded abalone.

- Geographic location for placement of seed.
- Techniques of seed placement.
- Abundance of kelp.
- Temperature requirement of species being seeded
- Size of the seed or juveniles being planted.
- Presence of potential predators at the site.

They also report on the results of several large-scale seed plantings of red abalone (*Haliotis rufens)* and green abalone (*H. fulgens)*. In subsequent plantings in Santa Barbara County in 1979-80, only two individuals out of 9900 hatchery-raised abalone

seed (average size 31mm) survived in the first trial. The second was more successful with 8900 seed planted with an increase of 600 to 800 abalone within four months. However, only 9 per cent of the seed remained in the study area. A later study off Palos Verdes reported only one per cent survival of seeded abalone.

Several important factors were considered to have affected success of these reseedings.

- The stress of transport and handling may have contributed to poor seed survival.
- Small abalone are cryptic and mobile, making survival assessment difficult until they reach a critical size.
- Habitat chosen may not have been appropriate.

Japan, however, has had success in reseeding various species. Lapota *et al* (2000) report on projects in Japan where success rates of 12-51 per cent were reached for small abalone (12-40 mm) and up to 70 per cent survival for larger abalone seed (70 mm+).

The development of abalone farming on the north west coast of South Africa has also been successful. Cook and Sweijd (1999) report experimental releases of *Haliotis midae* in an area beyond the natural range of the species resulted in 30 per cent survival rates at six months and growth rates similar to naturally occurring populations further south. The study incorporated a simple economic model based on production of 1000kg of seeded abalone. It plotted recapture rate against the number of animals necessary to be reseeded in order to produce one tonne of market-size abalone. The internal rate of return was not incorporated as the model was generated only to demonstrate the importance of the return rate in determining profit.

The model indicated that profit increases with increasing recapture rates. It also showed that seed cost has a relatively greater affect on profit at low recapture rates (< 20%) but that profit becomes less sensitive to seed cost at higher recapture rates. The authors recognised, however, that the profit margin would be influenced by factors not in the model, such as, volume, internal rate of return on investment, production cost, price and exchange rate. On the basis of this simple analysis, the authors were optimistic that acceptable profit margins would be achievable through reseeding abalone. They further noted that recapture rates of greater than 10-15 per cent were desirable, as profit margins were less sensitive above this level. Also, that production costs were critical, especially at lower return rates.

Scallop

The draft report for FRDC project 190/2000, entitled *Feasibility of Scallop Enhancement and Culture in Australian Waters* (Dredge *et al*), provides a thorough review of literature and experience of scallop reseeding, both in Australia and overseas. The following information draws from this report.

The report notes that, globally, scallop culture has been attempted in first and third world countries with mixed success and that there has been little consistency of operational conditions or economies for scallop culture operations that have been successful. Successful operations were linked to low labour costs, prolonged cultural and economic commitment to scallop culture, unique and favourable environmental conditions, or disregard for long term environmental impact. Unsuccessful operations

were often undercapitalised, lacked long term commitment, or were based on species with very slow growth and prolonged lags between settlement and growth.

Based on national and international experience and detailed economic modelling, the report suggests that reseeding of *Amusium balloti*, via seabed culture (as against hanging cage culture) would be economically and socially feasible.

The report also identifies specific deficits in information and technology requirements for reseeding of *A. balloti* in Australia that need to be addressed before economically viable operations can be developed.

- There will be a development phase needed to develop and translate hatchery technology to a fully commercial scale, consistent operation.
- The assumptions about natural mortality rates are based on limited factual basis and need testing.
- There is a need to determine optimum size of release. (This is a major cost variable).
- There is a need to develop transport procedures to take very large numbers of scallops from hatcheries to reseeding sites.

The report also examines the feasibility of hanging cage and seabed cultures for *Pectin fumatus*. Hanging cage culture appears economically feasibly in a small scale, low risk operation provided spat could be sourced from open water collection. Seabed culture was considered far less feasible given the need for hatchery-reared spat. Such an operation would require considerable investment, have a prolonged delay between investment and return and could only be considered with appreciable government support.

APPENDIX 2

Appendix 2: Summary of main points from *Reseeding of Grazing Gastropods and Bivalves into the Marine Environment – Potential Environmental Impacts and Management Control*

The following summary discusses the potential environmental impacts of reseeding marine habitats with mollusc species that would require specific assessment and monitoring and the policies now in place to deal with these potential impacts.

1. Impact on the genetic diversity of existing stocks;

The scientific opinions on the impact of reseeding on genetics vary from those of extreme caution to those less concerned about associated risks. Most agree, however, that genetic changes will occur in a hatchery, even in one generation of artificial spawning and hatchery rearing. Cross (2000) reports that some of these genetic impacts may not be evident in reseeded stock until at least the second generation of hybrids.

In terms of abalone, there is currently little information available on the genetic structure of wild greenlip and brownlip abalone populations around the Western Australian coast. To minimise the possible risk of affecting the genetic structure of local abalone populations, in accordance with Fisheries Management Paper No 133 *Abalone Aquaculture in Western Australia* genetic zones have been established, based on the commercial abalone catch zones.

Roe's abalone *Haliotis roei* occurs naturally in the surf zone from Shark Bay to the South Australian border. Information on the genetic stock structure of *H. roei* based on research conducted by the Research Division of Department of Fisheries indicates that there are only relatively small genetic differences between populations within the natural distribution of *H. roei* (Hancock, in press). Based on this information, there is little need for genetic zones for this particular species.

The tropical abalone *H. asinina* and trochus *Trochus niloticus* occur naturally in the north of Western Australia, however, little is known about the population genetics for these species. Consequently, juvenile stock to be placed into the marine environment should originate from broodstock collected from the nearest viable population, taking into account the planktonic lifecycle of the species and the hydrodynamics of the area to be stocked. In the absence of this information, broodstock should be collected from viable populations no further than say, 100 km from the area to be stocked. In circumstances where scientific data has proven that stocks of a particular species are genetically homogeneous within its natural range, broodstock can be selected for breeding from anywhere within that range.

All other species (for example, scallops and giant clams) should be considered on a case-by-case basis, however if little information is available on the population genetics for these species, it is recommended that the situation as it applies to tropical abalone and trochus should apply.

The other side of the genetic issue is the management of broodstock. Large numbers of broodstock should be used to produce the spat for reseeding. This will assist in preventing loss of genetic diversity through inbreeding and genetic drift. Specifically, the effective breeding number must be above a critical level, which will vary from

species to species and hence should be determined in liaison with a geneticist with expertise in the species involved in the reseeding project.

2. Risk of the introduction of disease and pests to wild populations;

The movement of molluscs from one area to another may spread disease and pests into areas where they are not naturally present and hence where there may be no natural resistance. Such diseases/pests include pathogens and shell fouling organisms. This latter does not appear to be an issue for hatchery reared stock given the filtration applied to incoming water for mollusc hatcheries. Given the above situations, all mollusc spat to be placed into the marine environment must originate from a hatchery and be certified as disease and pest free by the Fish Health Section of Department of Fisheries prior to release.

3. Physical disturbance of the benthic habitat during reseeding operations

There is a risk that reef systems to be reseeded with juvenile molluscs may be physically damaged during reseeding operations. In the case of abalone reseeding in the south of the State, it is expected that SCUBA divers will release juveniles on to the reef system and as such, physical damage will be minimal. However, to prevent disturbance of reef habitat, the use of specifically designed release cages that are retrievable and non-polluting for a limited period of time are to be used where appropriate, unless another environmentally sound method is approved. Impacts from the installation of any structures or equipment required for the release of juveniles should be minimised so as to ensure that the environmental values of the area are maintained.

In the case of reseeding intertidal reef systems with juvenile trochus, the stock is usually placed on to the reef platform by hand at low tide. The reef systems in the north of the State that are proposed for reseeding are either sandstone or limestone. Reef walking appears to have minimal impact on the biota of reefs of this nature. Coral coverage is naturally low and the algae that dominate the reef surface are adapted to resist physical disturbance. To minimise damage to coral, algae and encrusted sponges, workers can wear dive booties and need to be briefed on which biota are fragile and how damage to them may be avoided. Placing stock on to the reef system and monitoring its progress, cannot be undertaken by divers in these areas due to extreme tidal currents. However, the use of release or protection cages as described above can be used for some species such as giant clams, trochus and abalone.

4. Impact on the ecology of the marine system.

The reseeding of reef systems with hatchery reared juvenile molluscs raises a number of issues in relation to the impact on the ecology of the reef system. These include the possible impact on naturally occurring stock of the species to be enhanced and other species by competition for food and space.

Ideally, prior to undertaking any reseeding activity, the sustainable number of stock that can be placed into the system should be determined and the likely success of the stocking activity assessed and quantified. Scientific investigations of this nature are extremely complex and expensice to carry out, take considerable time to complete and would need to be undertaken by scientists with considerable expertise in this area of research.

Proponents in liaison with a reputable research organisation should undertake stock assessments and assessment of reef productivity on the habitat to be enhanced. These investigations should use recognised survey techniques for monitoring both the stock placed into the environment as well as the background level of natural stock recruitment.

More specifically, the monitoring program should:

1. Provide for the following assessments of the reef system to be undertaken:
    a) evaluation of the size structure of wild standing stocks of the species to be enhanced (if present); and
    b) evaluation of the presence of other ecologically similar organisms (that is, other molluscan grazers);
2. Ensure that the assessments are undertaken prior to the reef enhancement activities;
3. Ensure that where possible, a sub sample of the molluscan stock to be seeded are tagged or visually marked in some manner to allow identification (in a pilot trial, all reseeded stock should be tagged);
4. Ensure that assessments as outlined in 1 (a) and (b) above are undertaken on a regular basis post enhancement until the introduced stocks have grown to harvestable size; and
5. Provide for all results and evaluations to be forwarded to Department of Fisheries and the Evaluation Division of the Department of Environmental Protection.

Once stock numbers have recovered, to ensure the maintenance of natural population numbers, the licence holder will be only permitted to take a limited amount of stock from the nominated habitat. The Department of Fisheries, in full consultation with stakeholders, will determine the amount of stock to be taken by the licence holder on the basis of ecologically sustainable management practices.

Active management strategies, such as the control of naturally occurring predators around the release site, will not be permitted until such time as the success or otherwise or reef restocking is determined. In addition, to ensure minimal impact from nutrient inputs on the environment surrounding mollusc reseeding sites, reseeded stock must rely on natural sources of food - no artificial feed is to be used during the course of the reseeding program.

APPENDIX 3

Appendix 3 Licence conditions attached to current licences for reseeding of abalone.

Existing reseeding licence conditions reflect the policy positions taken in respect to sound fisheries management practices, protection of the environment and respect for the rights of other users. These have been mentioned throughout the main body of this paper, but appear below as a collective.

1 Juvenile greenlip and brownlip abalone to be stocked into the marine environment must be progeny of broodstock abalone that were sourced from within that genetic zone, in accordance with the zones set down in Fisheries Management Paper No 133 *Abalone Aquaculture in Western Australia.*

2 Juvenile Roe's abalone to be stocked into the marine environment can originate from broodstock abalone sourced from anywhere in Western Australia within the natural distribution of the species.

3 Juvenile tropical abalone, trochus and other mollusc stock to be placed into the marine environment must originate from broodstock collected from the nearest viable population, taking into account the planktonic lifecycle of the species in relation to the hydrodynamics of the area to be stocked. If insufficient information in relation to the lifecycle of the species or hydrodynamics of the area exists, broodstock should be collected from viable populations no further than say, 100 km from the area to be stocked.

4 All mollusc spat to be placed into the marine environment must originate from a hatchery and be certified as disease and pest free by the Fish Health Section of the Department of Fisheries prior to release.

5 Where appropriate, juvenile molluscs be placed on the reef platform by SCUBA divers to minimise physical damage. For some species in certain areas, the use of specifically designed retrievable and non-polluting release cages for a limited period of time is recommended. Impacts from the installation of any structures or equipment required for the release of juveniles should be minimised so as to ensure that the environmental values of the area are maintained. All workers involved in reseeding and monitoring activities must be briefed on which biota is sensitive to damage and how they may be avoided.

6. The licence holder (or nominated Research Organisation) shall establish a monitoring program that:

   a. Provides for the following assessments of the reef system to be undertaken:

      - evaluation of the size structure of wild standing stocks of the species to be enhanced (if present); and
      - evaluation of the presence of other ecologically similar organisms (i.e. other molluscan grazers);

   b. Ensures that the assessments are undertaken prior to the reef enhancement activities;

c. Ensures that where possible, a sub-sample of the molluscan stock to be seeded are tagged or visually marked in some manner to allow identification (in a pilot trial, all reseeded stock should be tagged);

d. Ensures that assessments as outlined in (a) above are undertaken on a regular basis post enhancement until the introduced stocks have grown to harvestable size; and

e. Provides for all results and evaluations to be forwarded to the Department of Fisheries and the Evaluation Division of the Department of Environmental Protection.

7. To ensure the maintenance of natural population numbers, the licence holder is only permitted to take a limited amount of stock from the nominated habitat. The Department of Fisheries will determine the permissible amount of stock to be taken by the licence holder on the basis of ecologically sustainable management practices.

8. Active management strategies such as the control of naturally occurring predators around the release site are not permitted.

9. Artificial feeding of molluscs reseeded into the marine environment is not permitted.