Sea Cucumber Ranching in the Northern Territory

A Discussion Paper

The Very Attractive Sandfish, *Holothuria scabra*

Aquaculture Planning and Management Paper

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1. Introduction and purpose

1.1 Purpose of this document

This discussion paper has been prepared to encourage involvement in the development of policy for the ranching of sea cucumbers in the Northern Territory. Sea cucumber ranching can involve the augmentation of the existing fishery, or the creation of a new extensive aquaculture industry where areas of sea bed are leased for the purpose of growing hatchery produced sea cucumbers. Most states have, or are the process of developing ranching policies for the various jurisdictions. This discussion paper has been based on a similar discussion paper from Western Australia (Borg, 2003).

Submissions are sought on issues relating to the management of the resource and the development of a sea cucumber ranching industry. Comments were sought initially from the Ministerial Advisory Council for Aquaculture in the Northern Territory, and various Northern Territory Fishery Managers. These comments have been incorporated in this discussion paper. Following consideration and incorporation of comments received on this discussion paper, a policy paper will be drafted for further comment by private sector stakeholders and other government agencies.

To this end, there are some important issues you may wish to address in your submission:

- In approving the use of a 'new' fisheries management tool, such as ranching, what factors must be considered?
- What level of risk would be considered acceptable? And are the social and economic aspects balanced with the biological and environmental?
- Adequate research and monitoring requires funding, which is not always available within the timeframes required for decision-making.
- With whom should final accountability for a particular ranching project lie?
- Are the proposed guidelines appropriate?

Although we have identified specific issues of interest, we seek your views on any or all of the matters in the document of significance to you and/or your group. If an issue has been overlooked please include it in your feedback.

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.

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

1.2 Introduction to the Trepang fishery

The Northern Territory of Australia has been home to sea cucumber, or sandfish, fishing since the 1700's when the Macassans, from what is now known as Sulawesi, travelled across the Timor sea to interact with the local Aborigines and to fish for this high value product. Minimal reliable data is available from the 1800's to estimate the extent of the fishing, or total landings, however estimates based on historical data indicate annual catches of around 800 tonnes were common. It is fair to say however, that Trepang was once Australia's most valuable export.

Fishing for Trepang in the NT underwent a significant period of low or no commercial exploitation until the 1980's when six licences were issued that covered the entire NT coastline. Two management areas now exist, east of Cape Grey to the QLD border, and west of Cape Grey to the WA border. Three licences operate within each management zone. Controls are also in place which limit the number of divers or collectors. Fishing is allowed from the coastline, to 3 nautical miles seaward from the fisheries baselines.

Sand fish prefer inshore sandy substrate areas rather than coral reef ecosystems and are often found is seagrass beds which are thought to be one of the triggers for larval settlement. Sexual reproduction occurs by broadcast spawning of eggs and sperm. The planktonic larvae spend up to 14 days in the water column before settlement, so there is potential for larval dispersal. Smaller sandfish seem to prefer shallow waters close to the coast while distributional data suggest that larger individuals migrate out to deeper water. One view is that larvae settle in shallow water and as they grow, migrate out to deeper water to spawn (Hamel et al., 2001). Genetic studies from Queensland indicate little genetic variability between spatially disparate populations of *Holothuria nobilis* (Uthicke and Benzie, 2000; Clarke, 2003). However Uthicke and Purcell (2004) found that sandfish stocks in New Caledonia show restricted gene flow at short spatial scales. This may be due to the island nature of New Caledonia and subsequent ocean currents.

Sandfish are collected by walking at low tides or by snorkel, SCUBA, or hookah diving. The total reported catch for 2002 was 207 tonnes which is slightly above the 5yr average of 180 tonnes. The CPUE was greatest in 2000 with just over 50kg per hour. In 2002 it had dropped to around 20 kg per hour. An analysis of the individual weight at harvest between 1996 and 2002 has revealed that it has remained stable at around 450-550g. Licensed fishers are able to take all sea cucumber species, however the most valuable species is the sand fish (*Holothurius scabra*). In other jurisdictions, where CPUE has declined, other species of sea cucumbers will then be fished. In the NT, *H. scabra* has remained the only species purposefully fished since the mid 1990's. In summary, when considering data for total catch, effort, species taken and mean individual weight of animals taken, the fishery appears to be in good shape.

Presently all six fishing licenses for sea cucumber in the NT are owned by a single entity, Tasmanian Seafoods. There is currently, no indigenous fishing, no recreational fishing, and no aquaculture of this animal. No further fishing licenses will be issued.

The fishery is currently undergoing assessment by the Environment Australia as an ecologically sustainable managed fishery. This will allow continued export marketing.

1.3 The Issue

In 1999, twenty-seven countries were carrying out ranching of more than 60 marine and brackish water species (Bartley, 1999) with the aim of improving catches from wild fisheries and aquaculture. New Caledonia and other Pacific nations have been assessing sea cucumber restocking and enhancement for a number of years (Purcell, pers comm).

Tasmanian Seafoods has expressed an interest in developing a pilot hatchery for sea cucumbers, with an eventual view to releasing cultured juveniles to augment wild fishery stocks. A similar project has been proposed for Southern Rock Lobsters in Western Australia (Borg, 2003). To that end, negotiations have progressed with DBIRD's Darwin Aquaculture Centre (DAC) for contracted sea cucumber hatchery research.

DBIRD feels it is important to have a clear statement of policy, as well as administrative and management processes in place to allow timely and transparent processing of any new proposals. This discussion paper therefore will discuss the issues relating to sea ranching of sea cucumbers and outlines the proposed processes to be used by the proponents and the government in ranching projects.

The main issues that require discussion and are addressed in this paper are

- Definitions
- Why do Ranching?
- Ecological effects of sea ranching
- Resource sharing and balancing competing uses of marine resources
  → Property rights and flow on effects (ie. 2nd generation)
- Options for Administration, Licensing, and management
- Generating a framework for application processing.

This paper is the initial step in the policy development process. It will be used as a 'comments generating device' in line with Aquaculture Policy Principle number 4–

> DBIRD will communicate with Territorians and consider their views on issues of public concern in a fair and transparent manner, based on science and risk-management approaches.

Recommendations for a framework for the development of extensive aquaculture enterprises, and ranched fisheries, are provided in this document.

Tasmanian Seafoods, the company with sole rights to fish for trepang in the NT, after purchasing all six licenses, has begun negotiations with the Darwin Aquaculture Centre to perform research on hatchery technology of sea cucumbers. The juveniles produced are intended to be released to the wild for later harvesting. This is by definition, a very low intensity form of aquaculture, and has the potential to support or augment wild populations of sea cucumbers and thereby increase yields. By the same token however, it remains a fishery, and is subject to all the Fisheries Management requirements of the NT and Commonwealth governments. The envisaged increased yields should lead to positive outcomes in terms of economic and social development, as required by the NT's stance for

ESD. A higher yielding fishery will generate more income and jobs, particularly in regional areas of the NT. In general it is the ecological implications which are the greater unknown.

Also, several remote aboriginal communities have expressed an interest in growing and harvesting sea cucumbers as a form of aquaculture. The aquaculture of the sea cucumber can occur in dedicated aquaculture ponds, sometimes in polyculture with other species such as prawns, in aquaculture effluent remediation ponds, or in specific sea leases, whereby an area of seabed is leased and stocked with juvenile sea cucumbers to be harvested at a later date. There would be very little day to day management required and this form of extensive aquaculture is likely to be culturally appropriate to several aboriginal communities on the NT coast.

Recently technology has been developed to reliably mass produce sea cucumber juveniles (Battaglene, 1999; Morgan, 2000). In many areas of the globe these animals have been exposed to unsustainable fishing pressures and catches have remained low for some time (Battaglene and Bell, 1999). In 1999 the sea cucumber fishery in Queensland was closed due to over fishing (Uthicke and Benzie, 2001). In some areas, particularly in the Pacific, restocking or stock enhancement of sea cucumbers in natural waters has been undertaken.

The danger with stock augmentation or ranching is to believe that just because we can, we should. Although it has its place in sound fisheries resource management, stock augmentation and/or ranching may not be the answer to all fisheries management problems; in fact, it is likely to be appropriate and effective only in relatively few situations.

The technology to breed certain species in hatcheries exists, but important questions need to be asked about the long-term benefits to the fishery, the ecosystem, society and the economy.

The most significant of these questions is “What is the biological risk?” - the real risk, not the perceived risk. A key consideration has to be conservation of fish resources and their environment, for without the resource and its environment, there is no fishery. There may be situations where there are strong, valid social or economic arguments for stock augmentation or Ranching to occur. A ranching project may be approved on these grounds alone, but not to the detriment of the sustainability of the fish and fish habitat.

Stock augmentation and/or ranching must be seen as part of a total fisheries management framework. Further, as fisheries management moves from managing fisheries sectors to managing fisheries as part of ecosystems, the primary driver for management decisions can no longer be extractive use – it must be a combination of the ecological, social and economic impacts. This must also be the case for sea cucumber augmentation and ranching.

The objective of this paper is to propose a process that will allow the decision makers to objectively assess the appropriateness, benefits and costs of any ranching proposal under Ecologically Sustainable Development (ESD) principles.

It is important to remember when reading this paper, that it is not attempting to say that sea cucumber ranching will or will not be allowed in a certain circumstance, nor does it attempt to provide a complete discussion of all the environmental, social and economic issues associated with ranching. It sets out a possible application and approvals process and provides some background information to illustrate the types of considerations that will need to be taken into account when deciding whether to approve a ranching application.

The final decision on any project would have input from a number of other groups or Departments with interest and legislative power over aspects of stock augmentation, such as the Lands Access Group within the Department of Infrastructure, Planning and the Environment. Proponents will be required to ensure any proposal meets the requirements of this Department prior to submitting an application to the Fisheries Group.

This multi-departmental responsibility for resource use that affects fisheries is one of the main issues the Fisheries Group faces in developing a policy for sea cucumber ranching. The nature and impacts of sea leases, and environmental effects of sea cucumber ranching will have a major impact on any proposal, as well as the sea cucumber management plan.

2. Definitions

The internationally ratified definitions recognise that when natural fish populations are enhanced with the addition of specifically procured specimens, the result is either a 'private gain' or the creation of a 'public good' (Bannister, 1991). These activities are -

- Ranching – Identifiable[1] stock released with the intention of being harvested by the releasing agency. (A private gain)
- Enhancement – Stock released for the public good without the intention of benefiting an exclusive user group. (The public good)

This paper is therefore dealing with ranching and / or aquaculture, as no other user group would benefit from the release of stock. Ranching of sea cucumbers, as undertaken in some Pacific Island nations, as well as in China, involves the introduction of hatchery produced juveniles between 10-30 mm in length, to suitable habitats. These are left to grow in the natural environment to be harvested by the stocking agency/company when they attain a suitable size.

For aquaculture ranching, the juveniles would be stocked to a specific lease area and harvesting would be restricted to occur within this area, and by the leaser, only. For fishery type ranching, juveniles are released to the wild within the licensed fishing management area and are harvested, by any of the licensed fishers. In this case by Tasmanian Seafoods.

[1] Stock may not always be identifiable, and this requirement cannot be enforced with sea cucumbers as no long term marking program has been successful.

3. Why undertake Ranching?

Bell and Nash (2003) compared the ideologies of restocking and stock enhancement. They defined restocking as 'restoring stocks to a point where they can sustain regular harvests'. Stock enhancement was defined as 'a process that increases yields by overcoming recruitment limitations'. As the modern-day sea cucumber fishery of the NT shows no sign of overfishing (although catches may be down in historical terms), the purpose of the ranching exercise is stock augmentation.

3.1 Fisheries Augmentation

Similar to other input and output fisheries management tools such as, size limits, the setting of quotas, gear restrictions and temporal restrictions, stock augmentation or ranching is a tool designed to increase the sustainable value of a fishery (Bartley, 1999). Ever since hatchery technology has been available, there has been interest in using the products of these hatcheries to enhance wild fisheries. Most aquatic organisms are highly fecund but with correspondingly high larval and juvenile mortality. So it is understandable that fishery managers look to bypass this high mortality stage with juvenile stocking as a tool to deal with many situations where there are fewer fish than in the past (Hilborne and Winton, 1993; Leber, 2002; Walters 2004).

Stocking can be used to try and keep up with demand for fish where the fishing effort is high and cannot be controlled for political or social reasons, or to more quickly rebuild wild populations that were historically overfished (Walters, 2004). Hatcheries have historically been seen as 'quick-fix' solutions to wide ranging problems of ecosystem management.

Fishery performance is usually related to environmental fluctuations. Variations in the natural environment, poor monsoonal rains or extended periods of hot weather, may impact on a species recruitment and age structures at particular sites. Alternately, there may be man-made changes to the marine environment that have affected populations. These changes include dredging, coastal development and pollution. There may have been overfishing of reproductive age groups in the past which limited recruits in the current harvest cohort.

The main question to be asked is – Is re-seeding the most appropriate fisheries management tool for the specific application? Unfortunately this is a difficult question to answer without comprehensive fisheries data. Re-seeding will not increase the carrying capacity of the system, which will likely fluctuate with annual cycles, but it may overcome a specific problem associated with poor recruitment such as cyclonic events or other temporal environmental damage, or juvenile habitat loss. Fisheries are sometimes limited by the amount of larval and juvenile habitat available, rather than appropriate late juvenile and adult habitats and resources.

Further, it is vital to establish why sea cucumbers are absent from an area prior to stocking. The reason may go beyond a simple recruitment failure and the stocking may even have adverse impacts on the receiving waters and habitats.

3.2 Aquaculture

Ranching of sea cucumbers for aquaculture purposes is attractive for a number of reasons. The hatchery technology is relatively straight forward, and reliable methods which yield high survivals are available (Morgan, 2000). Larvae are phytoplanktivorous and pelagic for approximately 2 weeks before settling onto diatom covered plates. These then graze the benthic diatoms for up to a month before being moved to sandy substrates at approximately 10 mm in total length (TL). Juveniles can be stocked to the wild at approximately 25 mm TL (approximately 2 months from hatching). These juveniles can be placed on the seafloor in an appropriate habitat type within a licensed lease area. There may be no form of stock security, and at harvest, only sea cucumbers from within the lease area can be harvested.

This extensive form of aquaculture is anticipated to have very little impact on the environment, especially if sea cucumbers are endemic to the lease area. The very low degree of inputs and management required may facilitate participation by a broad range of the NT population, including interested coastal aboriginal communities.

4. Decision making framework

The following framework (Chart 1. Taken almost without change from Borg, 2003) for fishery-based ranching is proposed to ensure that augmentation and ranching activities are put into the perspective of NT fisheries management. The framework shows that releasing juveniles is one tool among many, that are available to fisheries managers. The framework acknowledges that ranching and augmentation can be used as positive contributions to a well managed fishery. For example, augmentation may be used to address a naturally uneven distribution of a species within the fishery bounds. It may also be used to boost harvestable quantities of a species whose numbers are limited by larval or juvenile mortality (possibly due to habitat or resource limitations). Each shaded box within the framework is a question that must be considered before progressing to the next step.

Although the activities of ranching or augmentation by a licensed fisher, and aquaculture ranching, are considered legally different, the effects on the natural fishery resources and the fished species are likely to be the same. It is within this idea of ecosystem-based fisheries management that this framework has evolved. The decisions relating to the natural environment for aquaculture ranching will be the same decisions required as for fisheries stock augmentation. However issues relating to the management of the fishery in the top half of the framework will probably not interest the aquaculturist. The aquaculturist joins the framework at the point of the asterisk (*) where they are proposing ranching as an aquaculture business. One framework for both types of ranching has been used to show integration especially for the development and monitoring stages. Issues relating to leases and licenses will be discussed separately.

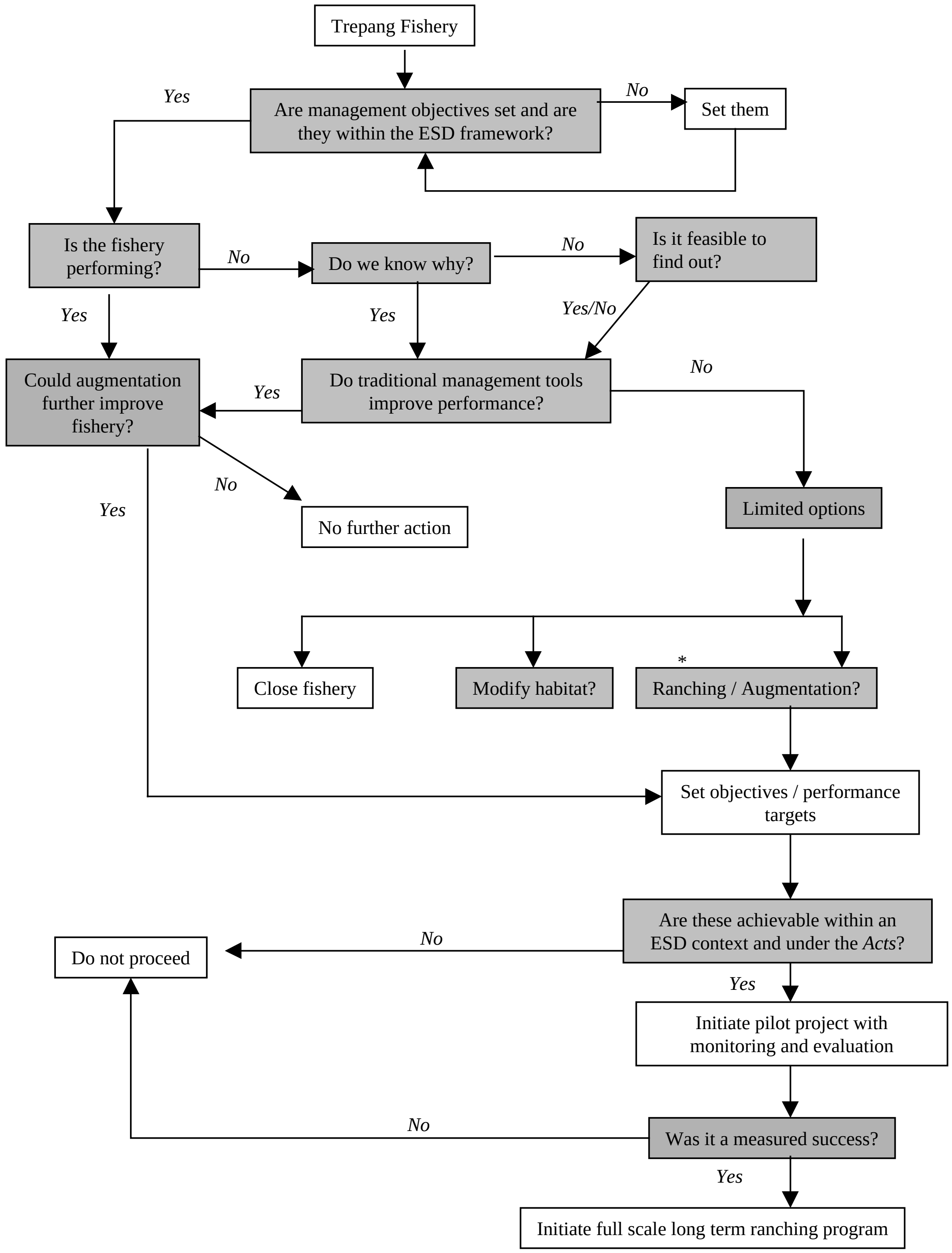

Figure 1. A chart for assessing sea cucumber ranching applications.

Are management objectives set and are they within the ESD framework?

4.1 *Are the management objectives set and within ESD framework?*

The NT sea cucumber fishery is currently undergoing Environment Australia (EA) accreditation for export marketing. EA will accredit a fishery that can show Ecologically Sustainable Development (ESD) as outlined in the EPBC *Act* 1994. Assessment of any enhancement project would need to take into account whether the proposed project complemented ESD goals of the fishery. 'Would ranching of sea cucumbers contribute to the ESD of the existing fisheries resources?' Work is currently under way to develop sea cucumber specific objectives for ESD components.

Commercial fisheries are managed under various types of management regimes and plans. Explicit management objectives including performance targets are essential for sustainable fisheries management. Having said this, performance targets set within objectives must be realistic. In many fisheries, there is not sufficient information to be able to set meaningful targets. In other fisheries, the data exists and fisheries have been managed on the basis of these. However, these targets are not set in concrete – they are regularly re-evaluated in the light of new information, and, where appropriate, changing or new resource use possibilities.

As with existing fisheries, user groups must be involved in the setting of objectives and targets for new or enhanced fisheries. Negotiating common objectives and then a plan for what can actually be achieved will present a challenge. There may be a big difference between a desired outcome and what can be achieved under ESD frameworks.

Is the fishery performing?

4.2 *Is the fishery performing?*

If a fishery is not meeting preset objectives and targets, it is likely to be due to one or a combination of threatening processes. There is a wide range of effects that have nothing to do with what is traditionally blamed for poor fishery performance (poor management / over fishing). These are primarily associated with human population growth and development in coastal areas. The challenge is to identify and understand the causes of poor performance in the particular fishery. In many situations, however, there may not be enough evidence to identify the underlying cause(s). There may be insufficient information about the stock/population of fish, or about the water body/system/fishery.

Do we know why?

Having identified threats (to the level possible) against achieving fishery objectives, the question must be asked - can these threats be mitigated? If not, there may be no point proceeding because management decisions, and subsequent actions (including stock augmentation), will not be effective. For example, if the habitat has been damaged, it may not be able to support an enhanced fishery. Part of the difficulty is that responsibility for different aspects of habitat management lies with a number of State, local and in some cases, Commonwealth authorities and hence fisheries managers may only be able to influence a small part of the total system within which the fishery operates.

Is it feasible to find out why?

Fisheries management decisions, by necessity, are often made without the benefit of all information, but not before assessing the implications of acting or not. Stock augmentation introduces a different dimension because, in the majority of cases, it involves introducing something new into a biological system and it is likely that not all the effects of this introduction would be known.

Welcomme and Bartley (1998) suggest that by applying elements of the precautionary approach to fish and fishery enhancement, such as risk analysis, implementing monitoring systems with defined levels of acceptable impact, and corrective measures in advance of adverse impact, it is possible to reduce the likelihood of an adverse impact.

The ESD precautionary principle states:
"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[2]

This principle doesn't say, "don't do anything unless there is perfect information", but it requires a meaningful attempt to assess the risks associated with actions at various levels of information/knowledge and then caution in action.

Is it worth finding out what is not known, or do we make decisions based on what is known? A risk analysis of different courses of action and a cost benefit analysis on options for obtaining more information should answer these questions.

4.3 Do traditional management tools improve performance?

Do traditional fisheries management tools solve the problem?

If the threatening process(es) identified as impacting on the performance of a fishery can be mitigated, then it is likely that a management strategy can be developed to address poor performance in a fishery. The first step is to look at traditional management tools to ascertain if these can address the problem(s) in the fishery, if in fact there is under-performance. The main traditional fisheries management tools are those controlling fishing activity and those protecting fish and fish habitat.

Fisheries managers throughout the world have two main sets of tools for managing fishing activity. Input controls include measures such as restricting the number of licences and/or boats, nominating a fishing season, closing certain areas to fishing, and boat and/or gear restrictions. The most extreme of these management systems is total closure of the fishery, either temporarily or permanently.

Output controls in commercial fisheries generally refer to catch quotas. These can be total allowable catches or individual allocations, and transferable or non-transferable. The most flexible, and most widely used of these controls in Australia is individual transferable quotas, however the system is not appropriate to all fisheries.

Could augmentation further improve the fishery?

If traditional input and output controls of a fishery do not improve performance, then other options should be considered including stock augmentation and/or habitat modification. Of course, there may be no indications that the fishery is under-performing, as is the case currently for the NT sea cucumber fishery (although historical data would suggest otherwise). However, there sill may be the option of improving the value of the industry by augmenting juvenile recruitment by the seeding of hatchery produced juveniles. For an

[2] Declaration from the 1992 United Nations Conference on Environment and Development, also known as Agenda 21

EA accredited fishery, this may only occur if ESD principles are adhered to according to the EPBC *Act* 1999. (Appendix 2).

4.4 Options for improving fishery performance

If traditional management tools cannot improve fishery performance, managers have a limited number of other options.

Habitat Modification

4.4.1 Habitat modification

Fishery managers may choose to restore/modify the habitat such that the natural populations increase without further assistance (this option could be employed in connection with the next option). Hartig and Kelso (1999) define habitat as "the physical, chemical, and biological factors that integrate to support a particular species or assemblage." A good knowledge of sea cucumber ecology, and the ecology of the whole marine system, would be necessary before any habitat modification would be considered. Also, this method of improving performance should only be considered where habitat degradation has occurred, or where a good argument can be put for 'artificial' habitats.

4.4.2 Stock Augmentation or Ranching

Stock augmentation

The second option mentioned is stock augmentation. This will work best when used as a component of integrated resource management. Stock augmentation will always have an impact on the ecosystem into which fish are introduced; however, the level of this impact on the existing stock or fishery will vary. Often it will not produce the results desired by some groups – the immediate availability of more fish to take or the gradual return to a past 'utopia'.

Welcomme and Bartley (1998) report that evidence from existing introductions implied that inland rivers throughout the world have benefited from well planned introductions. Also, there appears to be some success with marine enhancements where stocking involves 'fish' native to the area, such as Pacific salmon off the coast and in the rivers of the US, and chum and pacific salmon in Japan.

Leber *et al* (1995) suggest that successful marine enhancement depends on the reality of two hypotheses that would underlie any enhancement – that significant number of hatchery fish can survive in the wild; and that released hatchery fish will increase abundances, not displace wild fish.

Inshore enhancement of striped mullet in Kaneohe Bay, Hawaii, demonstrates that there is some potential for marine enhancement given a controlled approach to management (Leber *et al*, 1995). Similarly, Welcomme and Bartley (1998) cite some success from initial introductions of striped bass and American shad in North America, rainbow trout in New Zealand and Chile, and Kamchatka king crab in the Barents Sea. Appendix 1 provides more examples.

Where the fishery is affected by habitat loss or modification, or a non-heterogenous distribution, augmentation of the stock may be an option. Augmentation acknowledges the effect of the existing habitat loss or modification through the release of fish at a size where the habitat is no longer a limiting factor, for example where habitat damage has incurred in an estuary that provides the habitat for the juvenile phase of a fish. In this case, augmentation would involve release of fish at the size at which they would normally leave the estuary. The stock gets extra fish without actually treating the problem in the estuary. Of course the best option may be to attempt to remedy the recruitment failure, whilst at the same time, releasing hatchery produced stock.

Before deciding that a stock could benefit from augmentation, the ecological consequences should be considered. As we are discussing the implications of releasing hatchery stock to the wild, these same issues apply to aquaculture ranching.

5. Developing and assessing stock augmentation and aquaculture ranching projects

Set Objectives and performance targets

5.1 Set objectives and performance targets

Each proponent must be clear on what he/she is trying to achieve and set specific objectives and associated performance targets to allow ongoing monitoring of success. Objectives need to be set within the framework of other management in the area affecting the fish resources being enhanced.

The goals and objectives of any project must be clearly understood before commencement. It is also suggested that prior identification of assumptions and expectations concerning the performance and operation of the project are necessary for its success. There will be a number of external factors that could affect the success of the project – predators, accessibility to critical habitat, carrying capacity, food availability, temperature, salinity, habitat degradation. There may also be behavioural deficits in hatchery-reared sea cucumbers that will affect survival (Blankenship and Leber, 1995). Performance targets should be set against each of the objectives and be measurable and testable.

Are these achievable within ESD boundaries?

5.2 Are these achievable under ESD boundaries?

5.2.1 Ecological considerations

5.2.1.1 Genetic drift

Sea cucumbers that are released from aquaculture facilities may breed with local populations resulting in a genetic shift in the wild population that may have deleterious effects, making progeny more susceptible to disease or unable to withstand environmental changes. The risk of genetic shift can be minimised by ensuring local broodstocks are used. *H. scabra* was shown (Uthicke and Purcell, 2004) to have some differences over relatively short geographic distances but that these were most likely attributable to hydrographic influences. Another closely related species, *H. nobilis*, shows very little population differentiation over distances greater than 1000 kms (Uthicke and Purcell, 2004). Also, a significant number of broodstock should be used so as to maintain genetic diversity within the population. Equal numbers of each sex should be used.

5.2.1.2 Translocation of associated species

Associated species, parasites and pathogens, may be in or on the target species, or be in or on the transport medium. The risks of translocating a non-target organism, with the primary species, may be minimised through appropriate certification of hatchery stocks. Thorough veterinary examination, chemical treatment, appropriate quarantine and containment, and emergency contingency plans would minimise the risk of release of associated species. Risk may also be minimised through appropriate cleaning, treatment and disposal where appropriate, of transport equipment including the transport medium (water), vehicles, personnel, boxes, ropes, bags and nets etc.

5.2.1.3 Effects on endemic stocks

Care should be taken to assess the appropriate number of juveniles for release as over stocking could inhibit the chances of wild-stock recruitment. Ideally, information should be gathered on the natural stock densities and approximate survival rates of various life stages, for areas proposed for release of hatchery stocks. Although it is acknowledged that gathering this data takes substantial time and money.

If the population regulating factor (predation, habitat unsuitability, competition for resources) occurs at a life stage after the age of juvenile release, and is a factor which affects the carrying capacity of an area, then cultured and wild stocks will be competing against each other for these limited spaces in the population. This is an especially important factor in a small or depressed population as a larger proportion of the standing stock will have originated from a hatchery, possibly leading to a greater magnitude of genetic drift.

Further, if the carrying capacity of an area was filled in a single stocking event, the recruitment of juveniles for the following years would be reduced leading to a population dominated by a single year class. Ultimately this will result in a large harvest one year , followed by years of much lower production. This is not in the best interest of the fishery, the fishers or the market.

When assessing a proposal for fishery augmentation, or aquaculture ranching, details relating to the objectives and performance targets, as well as ongoing monitoring and evaluation must be considered.

5.2.2 Social considerations

There are two basic groups of resource users or sharers.

→ The non-extractive users who derive pleasure or are comforted in the knowledge that there is an unexploited resource out there.
→ The extractive users who want a sustainably exploited resource.

This discussion will focus on issues relating to extractive users. A number of issues regarding ownership of stock, access rights to areas of seabed, equity and the need for large areas of seabed for aquaculture purposes need to be addressed.

5.2.2.1 Ownership

The most legally crucial feature of sea ranching within a fishery, is that of property rights of the released fish (Howarth and Leria, 1999). In most jurisdictions, the release of cultured fish or aquatic life into 'the wild' (ie. an open system) will normally amount to relinquishing all rights of ownership over them, and no infringement of property rights may be claimed by a rancher where these fish are legally harvested by another person. As stated previously, this will not remain as an issue of contention, as long as Tasmanian Seafoods retains ownership of all the fishing licenses.

However, where extensive aquaculture is permitted, either within the bounds of the existing fishery area, including aboriginal owned seas, conflicts over ownership of released stocks may occur. Currently, sea cucumber fishermen are permitted to fish within all sea areas of the NT from the coastline (Low water mark?) to 3nm from the baselines, including embayment areas that have been excised from the barramundi fishery with the new closure lines. Also, there are currently no reliable methods of marking sea cucumbers, as there are for species such as salmonids (adipose fin clipping) or abalone (shell marking), so this may be a difficult conflict to overcome.

A sub-component of this issue, is in relation to recapture of ranched or released stocks. It could be argued, by the ranching enterprise that they have a right to harvest the entire crop of released individuals. However without being able to determine which are ranched individuals, an important question begs asking. Should this be allowed if it will cause detriment to the fishery or wild stocks? Survival estimates of sea cucumbers, from stocking to harvest, should be factored into harvest rates. (From this perspective it may be better to license a specific pilot scale area for stocking and harvesting ie. an aquaculture license).

Further, the issue of ownership of the next generations of sea cucumbers will need to be addressed, as the released stock may breed with wild stocks. Output restrictions may be able to address some of these issues although imposing new conditions on existing licenses may present some inherent difficulties of their own.

5.2.2.2 Access rights for aquaculturists

As Tasmanian Seafoods own rights to fish for sea cucumbers from the coastline to 3nm from the base lines, this effectively covers the entire area within the NT available for aquaculture leases.

Within the NT there are areas of coastline, some close to aboriginal communities, that form natural embayments. Several hundred enclosed bays (and in open bays, the tributaries) have been excised from the Barramundi Fishery under the 'Barramundi Fisheries Management Plan'. If these areas were to apply to the sea cucumber fishery, it may be possible to grant a developmental fishery license (S17) to a proponent to operate an area within these bays. However, at present the commercial fishery is entitled to fish within these bays.

In Canada (Orreggo, 1991), there have been several proposals to create ‘mariculture leases’ for ranching operations in bays adjacent to hatcheries (the assumed point of release). Section 27 of the Canadian Fisheries Act states –

> ‘No person shall fish in an area to which a lease or license applies, or set therein any fishing gear or apparatus, except by permission of the occupant, nor shall any person interfere with any such fishery’

A similar arrangement will be necessary for any NT ranching of sea cucumbers on leases. A lease area will need to be granted prior to issuing an aquaculture license or a S17 permit. This area will need to be excised from the trepang fishery, and negotiations for compensation with the existing license holders, and other stakeholders, may have to be undertaken. It would be prudent for the aquaculturists to select an area of seabed that has not been fished in the past and for which compensation may not be required.

5.2.2.3 Other species and activities

Issues relating to the sharing of the seabed resource with other fishery operations also need to be assessed. Other potential users of the seabed include trawl fisheries such as prawns, and mollusc ranching activities such as a potential scallop fishery, as is under development in Queensland. Scallops have a burying habit and are usually trawled from the sea bed. Trawl nets often include tines which effectively sieve the substrate and may potentially damage the trepang and/or disturb the benthos and the ecology of the seabed.

Issues relating to established leases within the sea cucumber fishing area should also be addressed. If for instance pearling companies want to diversify into sea ranching of sea cucumbers under their existing pearl leases, what are the implications? How is this administered? Do they have a right to fish for this product? Can they contract a licensed fisher to fish within the pearling lease? Do the license holders ‘own’ this resource anyway? Careful consultation and negotiations within the confines of the Fisheries *Act*, should be able to solve these issues without conflict.

Other activities such as the laying of large gas pipelines on the seafloor also have the potential to disrupt the sea cucumber fishery. Does compensation apply in these cases?

5.2.3 Economic considerations

Blaxter (2000) suggests that cost benefit analysis (CBA) for augmentation is rarely straightforward, especially in open systems. Costs for raising and releasing fish are usually identifiable, however, unless released stock can be accurately identified and monitored, yield per released fish is not usually available. Similarly, indirect benefits need to be accounted, such as employment associated with hatcheries and transfers of fish. Most of the successful attempts to evaluate costs and benefits have captured the obvious production costs and value of recaptured fish, but fail to understand intervening mechanisms of survival and mortality. There is a danger that by not including the less obvious costs and benefits, or those harder to quantify, the CBA may not accurately reflect the true situation.

Bartley and Casal (1998) report that most of the recorded ecological effects of introducing species were negative; however, reported socio-economic impacts were mostly positive and often outweighed the negative ecological impacts. Although it may not be possible to put dollar values on all of these costs and benefits, they do need to be acknowledged and attempts made to value them.

If the project can compliment ESD complicity for the fishery, then a pilot project should be initiated.

6. Ranching and Augmentation establishment, monitoring and evaluation.

6.1 Legislation and Management Objectives

All fishing and aquaculture activities in the NT are regulated under the NT Fisheries *Act* 1988. The objectives of this act are -

> " to provide for the regulation, conservation and management of fisheries and fishery resources so as to maintain their sustainable utilisation, to regulate the sale and processing of fish and aquatic life, and for related purposes."

Any sea ranching activities should therefore comply with the management objectives of the *Act* and the fishery. The legislation provides a number of tools for meeting these objectives, the most common being the regulatory devices of licensing and permitting. The objectives of fishing and aquaculture are commonly quite different.

The objectives of the ranching program should be clear and explicit prior to being enacted so that assessment and review can be carried out from time to time. Clear objectives also provide direction for management of the fishery or aquaculture venture. Is the ranching intended as a 'recruit-type' activity, where previous overfishing has required enhancement of remaining stocks? Or is the activity solely proposed as a 'harvest-type' activity where all market acceptable sea cucumbers will be harvested prior to restocking? Or is there some combination of the two?

Defining clear management objectives and plans with short and long term goals, harvest regimes, and quantitative measures of success, are recommendations made for a responsible approach to ranching and stock enhancement (Blankenship and Leber, 1995).

In general, the main objective of fishery ranching will be to release juvenile sea cucumbers into the wild to increase the number that can be harvested. The specific aim should be to increase standing stocks of all age classes (which implies regular recruiting – both wild and cultured) to the carrying capacity for the habitat. This will ensure a sustainable and highly productive fishery. The augmentation of wild recruitment with cultured stocks will smooth out years of poor recruitment and lead to a more predictable and valuable fishery. By the same token, in years of good wild recruitment, effort used to generate cultured juveniles may be wasted.

To determine an appropriate course of action, that is if the release of juveniles is warranted, acceptable or necessary, basic information is required to assess whether the fishery is performing to its maximum sustainable yield, and if not why not. Can traditional management tools be used acceptably to improve yields? What is the carrying capacity of different habitat types? Can various habitat types respond differently to juvenile stocking? Are certain 'growout' habitats under utilised because larval and early juvenile habitats are not available?

6.2 Licensing and Permits

6.2.1 Application from within the fishery

If an expression of interest for ranching was received from a licensed fishing company, three options are available. The simplest option would be to issue a section 16 stocking permit. This permit would allow the proponent to stock a certain number of health certified sea cucumber juveniles, in a specific area of the existing fishery under a specific protocol. Harvesting would continue as normal.

The second option would involve the issuing of a section 17 developmental fishery permit to which certain conditions could be placed such as in the pilot stages of the ranching.

The third option would be to require them, or anyone else who wants to farm sea cucumbers, to gain a sea lease over a set area, and operate this area as an aquaculture venture. They would be subject to all the requirements of a normal aquaculture license. They may need to negotiate with the other fishing license holders, as part of the licensing process.

6.2.2 Application outside the fishery

If an expression of interest was received from a proponent interested in aquaculture-based sea ranching of sea cucumbers, in other words not a licensed fisherman, several permits and licenses would be required. The applicant would need to negotiate with DIPE lands administration group to secure a seabed lease. Once tenure of the lease can be established, an aquaculture license can be applied for. This will undoubtably include some form of Environmental Management System, which may include a PER or an EIS. A section 16 stocking permit will also be required prior to releasing juveniles.

In Western Australia, the license for ranching-type activities are issued in two stages. Firstly a license to undertake a trial growout project is issued. The license has clear and defined objectives against which success or failure can be determined. If successful, a further license, allowing a larger scale project with long term objectives, is issued.

When a lease area is applied for the Lands administration group undertakes consultation within government and with the public. DBIRD fisheries group will need to consult with our stakeholders for objections to the granting of the lease over a specific area. If the proposed lease area is a known 'Hot-Spot' for any other activity, such as coastal net fishing, mackerel fishing or especially sea cucumber fishing, conflict will almost certainly arise. Negotiations with existing stakeholders will be necessary. If a lease area is granted, the traditional fishing industry will be excluded from this area, amounting to a reduction in the fishing grounds.

6.3 Establishing and assessing a pilot project

Pilot project

Once a project is assessed to be feasible on paper, it would enter a pilot phase during which environmental, economic and social responses to the project are monitored to determine its viability. It is essential that, for this pilot phase to proceed, there is a full assessment of all issues associated with the project.

The project would be licensed for the period of the pilot, with clear objectives/targets, monitoring strategies and evaluation techniques in place prior to the commencement of the project. Objectives/targets could include percentage increases in fishable biomass; percentage increases in reproductive biomass; target levels of catch per unit effort, etc. The pilot project would be large enough to allow the husbandry techniques (including tagging/marking) to be evaluated at a useful scale, but small enough so that any negative effects (e.g. displacement of wild stock or other species) would be minimised. Further, if the project were not viable, minimal loss of investment would occur.

White et al. (1995) suggest that the results of stock enhancements be measured against the objectives set out at the beginning of each project. The evaluation should include information about "(a) performance of the stocked fish (survival, body growth, and reproductive success); (b) effects on other fish populations (hybridisation and ecological effects, eg competition, predation, habitat alteration, and disease transmission); (c) effects on other members of native biota; and (d) effects on humans (catch rate and other measures of fishing quality; economic, aesthetic, and social effects; and ramifications for public understanding of and attitudes toward resource issues)". They also recommend a full economic evaluation, acknowledging both direct and indirect costs, something not usually undertaken in depth.

However, as Bartley and Casal (1998) reasonably suggest, it is only possible to accurately assess the impacts of an enhancement if there is an accurate assessment of the pre-enhancement ecological and socio-economic environments. In many cases some or all of this information will not exist – making monitoring and evaluation of enhancement projects very difficult in those situations. It is hoped that running pilot projects before full stock enhancement is allowed to continue will cause much of this information to be collected, not just for the project in question, but increasing the overall database upon which future proponents can draw.

As with reseeding, if a pilot project is not successful, it would be important to recognise why this has been the case. For example, it may have been affected by external environmental factors such that a similar project at a different time may be more successful. In addition, "natural fluctuations in marine stock abundance can mask successes and failures" (Blankenship and Leber, 1995).

6.4 Full-scale stock enhancement

Full-scale stock enhancement may proceed

A successful, viable pilot project may lead to the licensing of a long term, full-scale stock releases within a fishery or an area of water. Because of the ongoing nature of such a project, there will be a need for continuing monitoring of objectives and targets of the enhancement project. Without these, ongoing monitoring would have no basis and success could not be effectively measured or assessed.

Where the fish stock augmentation occurs within an existing commercial fishery, the activities needs to be assimilated into any existing fisheries management arrangements. Consequently, monitoring and evaluation of success in such fisheries must be assessed in terms not only of the augmentation itself, but also of its impact on existing uses of the resources or the area.

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APPENDIX 1: Evaluating restocking of sea cucumbers

Relatively new advances in the techniques of mass production of sea cucumbers has facilitated initiation of several restocking programs in the Pacific. However a lack of research on release methods and assessment of stock post-release has inhibited evaluation of the benefits of the restocking programs (Purcell, in press).

Restocking programs usually attempt to remedy over-fishing by 'artificially' increasing the numbers of breeding animals in a population. These animals will be protected until numbers return to a fishable level, and are then more stringently managed (Bell and Nash, in press).

A theme arising from restocking programs is the relatively high cost of culturing and producing the juveniles in a number high enough to impact on the breeding population (Purcell in press; Bell and Nash, in press). Early attempts at restocking juveniles usually resulted in high levels of mortality in the initial period immediately after release. For this reason the culturing of sea cucumbers for a 'put-and-take' fishery, or aquaculture business, may not be cost effective (Purcell, in press). However if initial survival of sea cucumbers can be improved then cost effectiveness may be achieved. Also, if sufficient numbers survive, and are protected from fishing for a period of time (2-3 generations) then increased natural larval production by the population, that is promoting self recruitment, could make the restocking program cost effective in the long term (Purcell, in press).

It is well recognised that in contrast to the growing volume of literature on culturing of sea cucumbers, the information available on restocking programs is limited. To ensure that restocking programs are effective, much research is required to determine the most appropriate release strategies for maximising survival and growth.

Dance et al. (2003) showed that juvenile sea cucumbers are vulnerable to predation especially by marine fish. Settlement of sandfish (*Holothuria scabra*) can occur on sea grass in shallow waters (Mercier et al., 2000) and distribution patterns suggest they migrate to deeper waters later in life (Hamel et al., 2001). Additionally, juveniles may survive better in micro-habitat features within the general habitat in which they live. Purcell and Blockmans (unpublished) found that certain microhabitat features accounted for a majority of the variation in the survival of cultured sandfish in the wild.

There are several factors that may contribute to the success of otherwise of a juvenile release of sea cucumbers. Transportation of the juveniles from the hatchery to the wild can be stressful and the most appropriate method needs to be found. Factors such as the optimal density and duration of transport need to be defined, as well as the most appropriate transport media. This may not be in water, as dry transport has been successful for other benthic invertebrates (Dobson, 2001; Heasman et al, 2003).

The size at release has also been found to be important in a number of species (Zhao et al., 1991; Bell, 1992; Munro and Bell, 1997). Release of the temperate sea cucumber *Apostichopus japonicus* into ponds has shown that survival is positively correlated to size at stocking (Chang et al., in press). However, it may be more cost effective to stock a very large number of smaller juveniles and suffer higher levels of mortality, than to on-grow them and stock at a larger size. These issues are currently under investigation in New Caledonia (Purcell et al., 2002).

Another related issue is the development of juvenile behaviours. Hatchery reared juveniles tend to be less cryptic that wild juveniles of the same size. A common problem of stocking marine invertebrates is the naïve behaviour of cultured juveniles particularly regarding refuge seeking (Schiel and Welden, 1987). One suggestion is to release sandfish at a smaller size to reduce naïve behaviours from long-term culture (Purcell, in press). Enclosures or cages for temporary holding could act as half-way-houses for stocked juveniles. Purcell and Blockmans (unpubl. pers comm) found a two-fold increase in survival inside enclosures that prevented entry by large predators.

The timing of release may also have a significant bearing on survivorship. Juvenile sandfish are known to have a daily burrowing habit, whereby they burrow during the day making them less vulnerable to predation (Mercier et al., 2000). The timing of release should not coincide with where and when known predators are active. Similarly the best opportunity for survival and growth of released juveniles has been shown to occur when juveniles are at a corresponding size in the wild (Purcell, in press).

With the volume of literature slowly increasing it is understandable that no study has comprehensively evaluated a restocking program to estimate viability. The difficulties lie in the lack of tag-ability of juveniles. Until suitable tagging methods are developed, research is likely to be limited to experimental designs involving multiple release sites and control sites such as a BACI design (Before-After-Control-Impact) (after Green, 1979). However due to large variability among replicate surveys, the power of such an analysis to detect a stocking effect is likely to be relatively low. In a 'Beyond BACI' design (Underwood, 1991, 1992) multiple control sites are used and surveys are conducted at multiple times before and after the restocking event.

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APPENDIX 2: Ecologically Sustainable Development (ESD) Principles

Under section 3A of the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC) the principles of ESD are:

A. Decision-making processes that effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;
B. If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
C. The principle of inter-generational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
D. The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; and
E. Improved valuation, pricing and incentive mechanisms should be promoted.