Seagrass

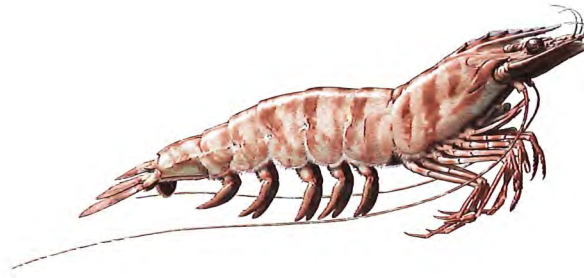## PRIORITIES FOR SEAGRASS RESEARCH IN AUSTRALIA

Research

Priorities for Seagrass Research in Australia

This booklet is a summary of *Seagrass in Australia: a Strategic Review and Development of an R&D Plan*[1] (short title *Seagrass Review*) with emphasis on its key features. It is *not* a substitute for the *Seagrass Review* itself, but only an outline. The *Seagrass Review* is targeted at all organisations and individuals that have direct or indirect influence on sustainable management of seagrass.

Seagrass is seen as one link in a 'critical chain of habitats' (see the *Fisheries Habitat Review*[1]) important not only to fisheries, but also to aquaculture, tourism, the protection of biodiversity, and the healthy functioning of nearshore marine ecosystems. The Seagrass Review was undertaken to assess:

- gaps in existing knowledge of seagrass ecosystems

- knowledge of links between seagrass and fisheries

- the state of the art in rehabilitation and restoration of damaged seagrass beds

- the state of the art in monitoring and assessment of seagrass

- relationships between research on seagrass and fisheries management

- and to develop a research and development plan for seagrass.

Although this review was commissioned in the context of FRDC's *Ecosystems Protection Program*, it was seen as having wider applicability. The whole community is a stakeholder in seagrass, as well as particular interests including fishers (commercial, recreational and traditional), fisheries management agencies, environmental management agencies, the tourism industry, scientific and educational groups, and conservation groups.

The FRDC *Seagrass Review*[1] follows and complements the *Fisheries Habitat Review*[1], reflecting the recent shift from viewing fisheries habitats as separate, unconnected places to viewing habitats as components of larger ecosystems. This change is consistent with approaching fisheries management in a comprehensive, ecosystem-based manner.

[1]See inside back cover for details.

Seagrass

Why review seagrasses? Seagrasses are a major element of coastal and estuarine ecological systems in Australia, from the tropics to the temperate zones but especially in the southern half of the continent. They are considered to be critical – at least, at some places and some times – to various commercially and recreationally fished species, and to shoreline stablisation. They are sensitive to a range of effects from human activities (urban, rural and marine), and the loss of seagrass from coastal waters near some major Australian population centres is well known. People can recognise seagrass beds, and they can see the declines that have occurred in much less than a lifetime, as the "blue line" has receded from favourite beaches around the continent. Of course, seagrasses are only one component of the complex ecosystem of the sea, and we do need to understand and protect the *whole* ecosystem, but seagrasses have been recognised as a key component and a good starting point in understanding the whole system.

Seagrasses are highly specialised marine flowering plants adapted to grow in soft sediments in nearshore waters. There are many species along both tropical and temperate coastlines of Australia. In fact, Australia has more seagrass species than any other country in the world.

Seagrasses are ecologically important. They provide a nursery habitat for juvenile animals and are believed to support various coastal fisheries indirectly. Tropical seagrasses are a source of food for dugongs and green sea turtles.

Although we know a lot about seagrasses, exactly what role they play is still unclear. Just how important are they? What would happen to our fisheries if the seagrasses disappeared?

There have been major losses of seagrass in Australia. Some of the possible causes are:

- nutrient addition from farm run-off

- sewage and industrial-waste dumping

- changes in water movement due to port construction

- turbidity from dredging and ship movements

- damage from boats and fishing gear

- damage from natural events like floods and cyclones.

But we want to know more about how the different pressures interact, how to reduce the threats, and how we can rehabilitate damaged seagrass beds.

As part of its *Ecosystems Protection Program*, the FRDC commissioned CSIRO Marine Research to review research on seagrass. How much do we know about seagrass? What do we need to find out? More importantly, what do we need to *do*?

Much is known about the place of seagrasses within the wider ecosystems of shallow waters, but there are gaps, and there are some points where we might ask how well founded our cherished beliefs are. FRDC wanted the knowledge gaps and uncertainties identified, to help it and other agencies in prioritising the funding of future research.

FRDC seeks better management of the resource not only as fish habitat but also as a habitat that Australians value for many reasons. CSIRO was asked to develop a strategic plan to guide future research work towards that outcome of better management.
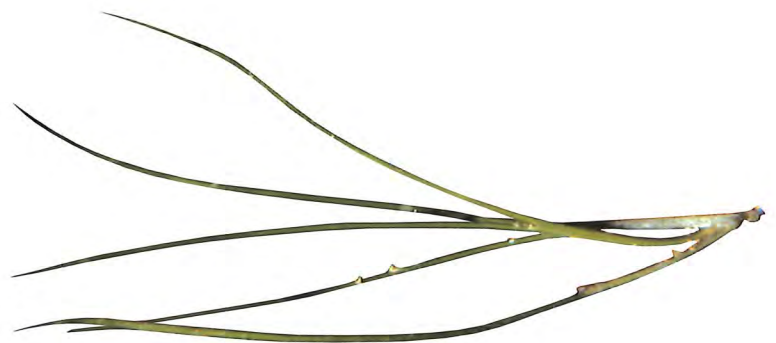
Seagrasses in Marine Ecosystems

The first chapter evaluates current understanding of seagrass communities Australia-wide, within the broad context of world-wide seagrass knowledge. The authors, Di Walker, Bill Dennison and Graham Edgar, examine the attributes of communities made up of different species of seagrasses, to determine whether seagrass form provides an indication of function, and hence the significance of particular seagrasses to fisheries.

They examine habitat effects, relationships to water movement and nutrients, and mechanisms of seagrass decline, and discuss what is known about food webs associated with seagrasses, and of the transfer of biological productivity between seagrasses and other components of the marine ecosystem. Even within a seagrass bed, there are important components other than the seagrass itself. Much has been learned about the effects of nutrient loading (from sewage or stormwater, for example) but the chapter concludes that more information is needed, especially about the large-scale effects of nutrients, and their effects on fisheries. It also warns against assuming that details learned in one place will apply in another.

We know more about temperate-zone seagrasses than about tropical ones, but our knowledge of all of them is fragmentary. Basic questions — for example, how much light do they need? — have been answered only for a few species. Our lack of knowledge hampers decision-making on issues such as the effect of turbidity from dredging, or the conditions under which we can successfully replant lost seagrass.

Seagrasses come in different shapes and forms and these are likely to have different ecological functions, especially as they relate to fisheries. Some small species (including the favourite foods for dugongs) turn over fast; others are slow-growing and long-lived, and slower to recover from environmental changes.

The working group identified nine areas of knowledge gaps, and suggested ways to address them. Some key areas are:

1   Northern Australian, turbid-water seagrasses on remote, inaccessible coastlines remain virtually unknown, especially in the Northern Territory.

2   Not much is known about the importance, as habitat, of seagrasses in wave-exposed conditions and in deep water.

3   We need studies (comparing different systems and locations) of how the wider ecosystems "uses" production from the seagrass system — seagrass detritus, microscopic drifting plants and animals, plants and animals attached to the seagrass blades, and microscopic plants growing on the sediment.

Seagrass and Fisheries

The second chapter, by Rod Connolly, Greg Jenkins and Neil Loneragan, examines the evidence for links between seagrass and fisheries resources. The report focuses on the reliability of that evidence. The review examines Australian work in detail, but includes some overseas studies.

We know that fish interact with seagrass – as nursery grounds, for shelter, for food, or they may be nourished indirectly by seagrass productivity that gets exported to other habitats. But much is still not known about these relationships, and the review shows that some of the widespread opinions are not as well supported as they should be. We also need to know more about the way in which seagrasses relate to other adjacent habitats – algal beds, mangroves or bare sandy areas, for example.

So, it is still not clear what a loss of seagrass really means for the fisheries. And all these questions have to be asked on a fairly large scale, because of the ways in which fish (and other animals and ecosystem components) move around with the currents in the sea.

The authors note, amongst other things, that less is known in tropical than in temperate Australia. We have to be concerned, of course, not only about the importance of seagrasses to fisheries, but also about the effect of fisheries on seagrasses; these effects might be direct (by damaging the habitat), or indirect (e.g. by removing predators causing other species to proliferate, or, in the case of aquaculture, introducing nutrients or toxins).

In conclusion, the working group identifies 17 major gaps in our understanding, and recommends specific research to address those gaps. A few of the 17 gaps are:

1 Associations between finfish and seagrass in tropical waters are virtually unknown. The nature of the links with seagrass (feeding, protection from predators, protection from physical disturbance) is still poorly known for many species. Understanding these links is important in predicting the effects of changes in seagrass extent on commercial fish.

2 Changes in juvenile fish and decapods before and after seagrass loss are poorly understood. Baseline studies over wide areas and relatively long times are needed, to measure how much the system naturally varies, so useful comparisons can be made after episodes of seagrass loss.

3 The importance of exported seagrass detritus to commercially important fish in other habitats is poorly understood. What is the effect of seagrass loss on these species? Seagrass meadows may not all be equally valuable; it is critical to determine the importance of size, shape, and spatial arrangement of meadows, relationships to water currents, and relations with other habitats (e.g. unvegetated areas, mangroves, deep water, sand bars).

Seagrass Repairing the Damage

Restoring a damaged seagrass bed is difficult but we are learning how to do it. We are finding out under what conditions it is likely to work at all, what species to use, and the right techniques for 'gardening' seagrass. Restoring the full, complex functioning of a seagrass-based ecosystem, however, is a more difficult challenge.

This chapter was prepared by Des Lord, Eric Paling and David Gordon. It reviews international experience then concentrates on Australian projects in the restoration and rehabilitation of seagrasses. It identifies the factors that are important to success, although most of these have yet to be investigated for most seagrass species. Consequently, at this time no projects in Australia can unequivocally demonstrate creation of a permanent, functional seagrass bed out of transplanting efforts. Nor have techniques been tested to the degree that a detailed "instruction manual" can be given for particular seagrass species or habitats.

Nonetheless, there is enough experience available to enable the authors to identify the important issues in seagrass rehabilitation and restoration. In making recommendations for future research the working group argues that restoration and rehabilitation depends on a thorough understanding of the system being restored, and therefore that it would be prudent to undertake restoration programs in concert with well constructed programs of research into the fundamental characteristics of seagrass.

The authors give detailed recommendations for a nationally coordinated effort to develop the technology for seagrass restoration in a variety of conditions. The knowledge gained will not only be valuable in Australia, but also could be marketed to neighbouring countries.

Watching Seagrass Grow

A monitoring program is an important aspect of managing any natural ecosystem. It can provide early warning of trouble, and can help determine whether our efforts to correct past mistakes are working.

For much of the coast of Australia, especially in the north, we still don't even have a map showing where seagrass is found. But monitoring is more than mapping. We need to develop monitoring techniques that are clearly related to the things we value about seagrass, techniques that work well, and techniques that are reasonably economical. This is a tall order. We can measure seagrass area from aerial photos, but is it area that matters? Maybe it's "plant health"?

In this chapter, Mervyn Thomas, Paul Lavery and Rob Coles review the current status of knowledge and methods for monitoring seagrass. For each example reviewed, they considered the objectives of the work (including relevance to management), the monitoring methods adopted, the spatial and temporal scale (and their relevance to the stated objectives), the statistical treatment adopted and the use of explicit data quality processes.

The chapter identifies 9 specific research priorities, and recommends that a national strategy for seagrass monitoring should be developed. The strategy should be based on an understanding of the relationship between seagrass distribution and productivity on the one hand, and fish stocks and biodiversity on the other. Developing this knowledge must therefore be a priority for seagrass research. Thus, the recommendations for research and development in monitoring *include* a call for the kinds of "understanding" research identified in other chapters of the *Seagrass Review*.

Amongst the nine research priorities, some examples are:

1   There is more work to be done in mapping the distribution of seagrasses, especially in the tropical north and northwest coasts of Australia.

2   We need a subtle knowledge of the role of seagrass, so that monitoring can do better than merely measuring area or biomass.

3   Geographic Information Systems and Image Analysis systems can be used to map and monitor changes, but there are difficulties with the current tools. To use them on the right scales, to estimate errors correctly, to take account of our understanding of how the ecosystem works, and thus to provide dynamic support for decision-making, is an exciting challenge for Australian research.

4   The chapter identifies a lack of skilled people – in taxonomy (the classification of plants and animals) and in statistics and information technology – as a major barrier to establishing a good national monitoring program.

We can't address all those gaps instantly, so the authors conclude that the current challenge is twofold:

1   To develop an interim strategy for mapping and monitoring that acknowledges our imperfect understanding, and

2   To instigate research that will provide that missing information, and education to supply the missing skills base.

Ultimately, we may have a suite of monitoring techniques ranging from satellite photographs for the big picture to teams of community volunteers filling in the fine-scale details.

Seagrasses and Management

Australia has complex legislation and administrative arrangements for managing marine systems, including seagrasses. Marine protected areas, for example, are just one of the available management tools. This chapter, by Duncan Leadbitter, Warren Lee Long and Peter Dalmazzo, examines issues confronting seagrass managers, and the information they need. The authors sent a questionnaire to managers, from which they present the requirements identified *by* managers.

The kind of information requested by the managers has much in common with the findings of the other working groups; in particular, the managers, too, recognised the needs for inventory; for better understanding of the links between seagrass, fish and fisheries; for better understanding of the habitat and environmental requirements of seagrass species; for conceptual models that would enable the right questions to be asked; for information on natural variation in space and time, which is needed to underpin all management of human impacts; and for understanding of the links between human activities and seagrass health.

The chapter stresses the need for cooperative arrangements, because managing seagrass depends on managing other systems, often far removed and under completely different managers (such as upstream catchments). The chapter proposes a detailed, national action plan for seagrass management in Australia that depends on cooperation, information sharing, and improvement of standards. The following key actions are proposed to improve seagrass management:

1   Establish/improve and maintain links between managers and researchers,

2   Develop networks for information sharing,

3   Develop collaborative research, development & extension,

4   Improve standards for impact assessment and rapid area assessments, and

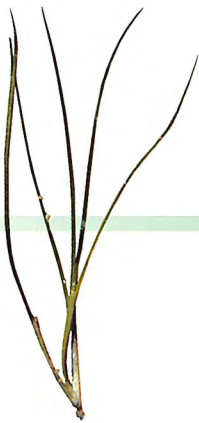5   Improve standards for assessment of seagrass management programs.

A national action plan, as proposed in this chapter, cannot be implemented by FRDC alone, but needs collaboration between many agencies. The R&D Plan developed from the *Seagrass Review* does, however, recommend ways in which FRDC can work towards the aims of such a plan.

Seagrass Research

WHERE TO FROM HERE?

Where to from here?

The principal authors and editors of the *Seagrass Review*, Alan Butler and Peter Jernakoff, with the advice of the steering committee, developed a plan to guide FRDC's own future investment in seagrass research and development, *and* its interactions with other agencies. This report may have originated in a concern for "fish habitats", but seagrass is important in many ways and the management of seagrass is the business of many people. The R&D Plan proposed in the Seagrass Review has been further discussed amongst people from several agencies and the outline given here reflects those discussions.

FRDC has undertaken the initial development of this R&D Plan on behalf of a much wider group of stakeholders. As far as FRDC is concerned, the plan falls within the FRDC Ecosystems Protection Program, which has as its goal: *to protect the Australian ecosystems upon which fisheries and aquaculture depend.* What we propose here is a cooperative approach to R&D concerning seagrass ecosystems; we call it the *Seagrass Initiative.* The *Initiative* is outlined here. More detail is given, as a proposed R&D plan, in the *Seagrass Review* but the details of the *Initiative* will have to be agreed by all those involved in it.

- The aims of the *Seagrass Initiative* are to enhance our understanding of the ecosystem of which seagrasses are a part, particularly of the linkages between seagrass and fisheries productivity, and to promote research and management to stop the loss of seagrass and enhance its restoration.

- Even if we were viewing this as a plan concerning "fish habitats", to achieve these aims would require the active involvement and support of FRDC's stakeholders and researchers, and the beneficiaries of research results.

- There is, however, a large number of agencies with management responsibilities that impinge on seagrasses and, amongst those agencies, a significant number with R&D responsibilities. The stakeholders in the health of seagrass systems go well beyond the those concerned with fishing. The involvement of all stakeholders is necessary, and it is essential that these responsible agencies work in collaboration with each other and with the community. The *Seagrass Initiative* is intended to involve all of them.

The *Seagrass Initiative* has a role in fostering research...

The *Seagrass Review* identifies a large number of gaps in our knowledge. The report identifies priorities amongst these knowledge gaps under the headings of:

- Inventory and data archiving

- Monitoring

- Ecosystem understanding

- Relationships between seagrass and the productivity of fisheries

- Human impacts

- Protection, restoration and rehabilitation of seagrass beds

These research areas are complex and interdependent. Further, all of them require consideration of the relationships between seagrasses and other components of the marine ecosystem – seagrasses do not exist in isolation. To appreciate the complexity underlying these six broad headings, you need to refer to the full report of the *Seagrass Review*. Within each of these areas, there are many specific research questions; the priorities assigned to these questions are likely to differ between different agencies and stakeholders.
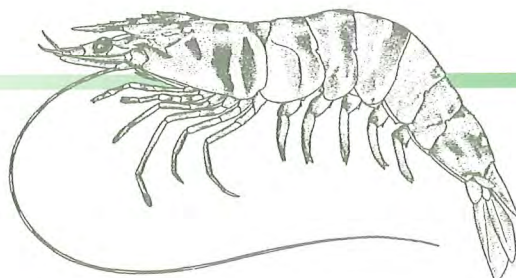
... but not on its own.

The most important aspect of the R&D Plan is coordination, communication and collaboration between multiple agencies and stakeholders (see figure below). The *Seagrass Review* gives detailed suggestions about how this might be done; the important thing is that it be done by one means or another, to ensure that research truly does contribute to the outcome of better management.
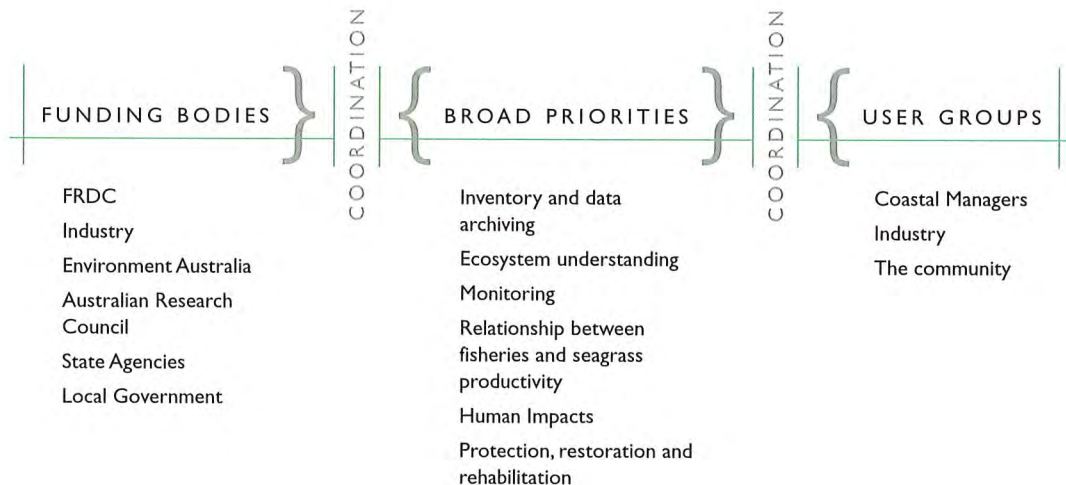
Tackling the research priorities ...

The Review proposes that the *Seagrass Initiative* should deal with the following priorities under the six research areas listed above. There are detailed recommendations under each heading in the *Seagrass Review*, and the following is only an outline.

Inventory and data archiving

Priorities are:

* broad-scale resource inventory of seagrass distribution in the tropics

* mapping techniques for turbid waters

* development of methods for mapping and monitoring, including:

  * methods for critically examining inventory techniques and assessing reliability of maps

  * appropriate statistical approaches — appropriate treatment of spatial uncertainty especially for mapping change over time

  * techniques for handling meta-data — protocols for handling and archiving data including storage of adequate metadata about field methods.

FUNDING BODIES	COORDINATION	BROAD PRIORITIES	COORDINATION	USER GROUPS
FRDC		Inventory and data archiving		Coastal Managers
Industry		Ecosystem understanding		Industry
Environment Australia		Monitoring		The community
Australian Research Council		Relationship between fisheries and seagrass productivity		
State Agencies		Human Impacts		
Local Government		Protection, restoration and rehabilitation		

Monitoring

It will not be possible for managers to interpret changes in a system, hence decide how to act, until they have both a statement of "natural" variation in space and time, and monitoring methods capable of detecting and estimating the sizes of any changes against that background, with understood reliability and precision. We need:

- development of new monitoring techniques

- techniques to integrate spatial data and temporal data

- data quality protocols for use in time-series analyses

- and, again, protocols for handling and archiving data including metadata.

These methods, however, need to be based on a conceptual understanding of the system; that understanding tells what variables are important to monitor.

Ecosystem understanding

The review proposes a program aimed at answering questions about ecosystems in several locations, selected for economic or other attributes which would justify the investment of a significant collaborative research effort.

The aim of this work would be to develop and test:

- models of seagrass ecophysiology, ecology and ecological interactions applicable to several, selected growth forms of seagrass and several, selected physical/climatic situations.

A number of issues would be encompassed by such conceptual models. Not all of them would necessarily be investigated in detail in each case. Those issues include:

- trophic pathways linking with seagrass beds

- critical light level values for specific seagrass species

- effects of fluctuating light regimes on seagrasses

- quantitative estimates of the role of seagrass detritus as a food source (compared with other sources of primary productivity) and critical tests of hypotheses, including not only fisheries but also the conservation value of seagrass productivity

- consequences for secondary production under seagrass decline

- investigation of the roles of habitat size on habitat diversity, function and survival

- knowledge of natural variability of seagrasses and their biota in space and time; this need, identified, by several groups, refers not only to description of *patterns*

but also to variability in ecological *processes* – dynamics of populations, fluxes of nutrients, etc., all must be described with measures of spatial and temporal variation

- role of spatial patterns and interactions ("landscape ecology") in explaining seagrass distribution and abundance

- the relationship between landscape ecology and fisheries

- investigation of stability and persistence of natural seagrass beds – compilation of seagrass population growth and coverage rates for defined ecological regions.

The report stresses the high priority of these "process" studies. No-one, however, suggests *delaying* management while those studies are done! Management action and further development of understanding must proceed together.

Relationships between seagrass and the productivity of fisheries

Working groups identified the following knowledge gaps:

- mechanisms explaining relationships between fish and seagrass – hence ability to predict effect on a fishery of seagrass loss

- fisheries utilisation of 'productive' seagrass meadows (e.g. Potential yield from seagrass meadows of commercially important species)

- the need to establish direct empirical links between specific seagrass species and fisheries production.

Human impacts

Questions raised by managers included:

- What are the system-scale effects of nutrient loading?

- What are the critical nutrient levels to initiate shifts in community composition?

- What are the responses to changes in habitat quality resulting from specific human actions?

- What are the impacts of introduced pests on seagrass?

- What are the impacts, if any, of trawling gear on seagrasses in northeast Australia?

- What are the impacts of aquaculture on seagrasses?

The *Seagrass Review* suggests that these questions be addressed at the target areas chosen for the above 'understanding' studies.

Protection, restoration and rehabilitation

Protection

Questions like: 'What is the minimum size for Marine and Estuarine Protected Areas'? cannot be answered without the 'ecosystem understanding' called for above. In the course of those studies, it will become possible to ask questions like: How much seagrass must be preserved? Where must it be preserved? In what state must it be preserved? Is it better to protect all habitats in a defined, mapped area, or all habitats of a particular type?

Restoration

There is a strong view that the proper approach is to avoid destroying habitat, rather than to hope that we can later restore it. Nevertheless, given the extensive seagrass loss around Australia, the *Seagrass Review* advocates the development of methods to restore damaged seagrass areas. These, again, depend on understanding of ecological processes, and the Review recommends that a program of restoration research be established in the first instance, at locations selected for large-scale, multi-faceted, cooperative studies.

The key points of that program are:

- Identification of a range of key representative seagrass habitats around Australia, which can form the basis for a nationally coordinated effort and selected to take account of the degree of threat to regional seagrasses

- Identification of local sites within each representative habitat type where experimental seagrass restoration efforts could be successful

- Development of a protocol and procedures for assessing techniques for planting or transplanting seagrasses

- Implementation of pilot trials

- Implementation of programs to monitor and evaluate the performance and success of pilot and experimental restoration efforts

- Implementation of research on seagrass biology specific to the development of seagrass restoration techniques.

Glossary

AIMS	Australian Institute of Marine Science
ARC	Australian Research Council
ASIC	Australian Seafood Industry Council
Critical Chain of Habitats	idea introduced in the *Fisheries Habitat Review* to reflect the fact that fish live in different habitats at different life-stages, and that the habitats are linked in many ways, for example through the movement of animals and plants, and the movement of organic material with the currents.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EA	Environment Australia
FRDC	Fisheries Research and Development Corporation
GIS	Geographical Information System
Recfish Australia	The Australian Recreational and Sport Fishing Industry Confederation Inc.

Seagrass

This report follows and complements the *Fisheries Habitat Review* (below). It was prepared by a team of 17 scientists from CSIRO, universities, state government agencies and industry (two Principal Investigators and five working groups each of three people). The work was guided by a steering committee consisting of the Principal Investigators and working group leaders, and representatives from FRDC, AIMS, Environment Australia and the fishing industry (ASIC and Recfish Australia). The Principal Investigators based their report and R&D Plan on the reports of the working groups, and asked the Steering Committee, and four independent experts, to review it before finally submitting it to FRDC.

The full report: *Seagrass in Australia: Strategic Review and Development of an R&D Plan* is available from CSIRO PUBLISHING for $59.95.

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It may also be accessed via the internet at http://www.publish.csiro.au/seagrass

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The *Fisheries Habitat Review*

The full report of this review is:

Cappo, M., Alongi, D., Williams, D., and Duke, N. (1998). *A review and synthesis of Australian fisheries habitat research*. 3 volumes. AIMS, Townsville.
FRDC project # 95/055. This is referred to as the *Fisheries Habitat Review*.

There is a short summary booklet available, and all 3 full volumes are available on CD-ROM from:
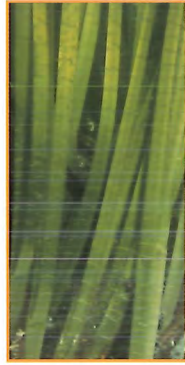
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The *Review* is accessible at:

http://www.environment.gov.au/marine/manuals_reports/coastnet/afhr/index.html
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