Marine Fish Habitat Research
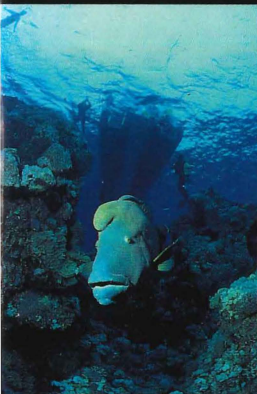## STRATEGIC PLAN
2000 – 2002

a whole of ecosystem approach

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Department of **Primary Industries**

Marine Fish Habitat Research
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Mission

To conduct research that generates knowledge regarding the roles of marine habitats and ecological processes in fisheries production and sustainability.

Goals

The Marine Fish[1] Habitat Research Program will address the research needs of management by addressing the following goals:

1. To determine which habitats or combinations of habitats are used by various fish species and what features facilitate or restrict the movement of fish between those habitats.

2. To document and monitor the extent and status of those fish habitats;

3. To determine the relationships between the status of fish habitats and subsequent fisheries production and sustainability.

4. To determine the effects of natural ecological processes (including interspecific interactions) on fisheries resources;

5. To determine the effects of human activities on fish habitats and their associated fisheries resources.

6. To determine the effects of habitat enhancement and rehabilitation on fisheries resources.

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1 For the purposes of this document, the term 'fish' refers to any aquatic animal (as defined under the *Fisheries Act 1994* (Qld)). This includes representatives of all animal phyla, including sponges, cnidarians (jellyfish, hydroids, sea anemones,corals), flatworms, roundworms, segmented worms, molluscs, crustaceans, echinoderms, true fish, other chordates and around 23 less well-known phyla.

Introduction

Fishing is a vital feature of Queensland's economy and way of life. The commercial fishing industry employs about 8000 people, generates over $400 million a year, and provides seafood for Queensland households and an expanding export market. Recreational fishing involves about 800 000 Queenslanders and visitors each year, has similar direct economic benefits to commercial fishing and is a significant feature of the Queensland lifestyle.
Both of those fishing sectors contribute to the State's desirability as a place to live and popularity as a tourist destination by providing high-quality seafood and recreational opportunities. Fishing is also a fundamental component of the culture of indigenous people in Queensland.

The social, cultural and economic benefits of fishing depend upon the continued productivity and sustainable exploitation of Queensland's fisheries. These in turn depend directly on the status of the ecosystems and habitats in which fished species exist. For this reason, the Marine Fish Habitat Research Program will conduct research that contributes to the effective management of fish habitats and fisheries in general.

The Marine Fish Habitat Research Program will bring a 'whole of ecosystem' approach to Queensland fisheries research. Division between fisheries stock research and fisheries habitat research is detrimental to our understanding of the linkages between the two. Through an integration of fisheries stock, fish habitat and marine ecological research, this program will generate knowledge of the interactions between fisheries stocks and the ecosystems upon which they depend. This knowledge will contribute to more effective management of Queensland's fisheries resources for optimal production and sustainability.

The intent of this Strategic Plan is to facilitate the development of an integrated and well-coordinated program of research that addresses the most fundamental and important issues related to marine fish habitat in Queensland. Research will focus on species of economic value and the species they interact with, as well as species of relevant scientific interest.

Benefits of Marine Fish Habitat Research

The Marine Fish Habitat Research Program will provide a number of direct benefits to Queensland fishing industries, fishery and environmental managers and the community as a whole. This program will:
- improve our understanding of the roles of habitat in supporting fisheries;
- generate knowledge regarding the effects of human activities on marine fisheries resources;
- provide essential information on which to base management policies and actions;
- support ecologically sustainable development of Queensland's fisheries;
- contribute to the maintenance of healthy marine ecosystems;
- enhance the image of Queensland as a producer of 'clean green' seafood;
- support fish stock research by improving our ability to understand factors influencing those stocks and our ability to predict trends in fisheries resource status;
- address community and industry concerns about the effects of habitat degradation on fisheries production and sustainability, and on marine ecosystems in general.

The Marine Fish Habitat Research Program will take advantage of new opportunities for fisheries research in Queensland. This program will harness the support for fish habitat research that exists both in the fishing industry and in the wider community. It will enable DPI to access a wider variety of funding sources and provide opportunities to further our collaborative links with other agencies. This program will also address the recommendations from recent reviews (Cappo et al. 1998, Butler & Jernakoff 1999) and contribute to setting research directions for the new DPI Fisheries Institute.

Management needs

Recent reviews have highlighted the incomplete nature of our knowledge of the habitat needs of many of our important marine fish species (Cappo et al. 1998, Zeller 1998, Butler & Jernakoff 1999). Similarly, we have only the most rudimentary knowledge of the contributions that those fish habitats make to overall fisheries production. More detailed knowledge is needed to determine and quantify the effects that human impacts on fish habitats may have on fisheries production.

Marine fish habitats are under pressure from human activities in marine, coastal and catchment areas. These pressures are likely to increase as population growth leads to increased demands for real estate and other development in coastal areas; and need for greater agricultural and aquacultural production in coastal and catchment areas. Managers must make decisions on the regulation of human activities and the amounts of habitat to be protected without detailed knowledge on the roles and importance of those habitats. To do this, they have to resort to general assumptions and the precautionary principle to try to ensure fisheries sustainability.

Fisheries managers need to know:
- the relative importance of different habitats to fisheries;
- the impacts of human activities on fish habitats;
- the extent and condition of habitat that needs to be protected to ensure sustainable fisheries production;
- optimal mitigation for the adverse effects of habitat degradation and loss.

Current strengths

The Fisheries Group of DPI currently conducts productive, credible and internationally recognised research into marine fish habitats. As an organisation, we have attained this status through our achievements in the mapping and monitoring of vegetated marine fish habitats, e.g. seagrass beds and mangrove forests, and previous research on links between habitats and fisheries. The approach of the Marine Fish Habitat Research Program will be to maintain and add value to those ongoing projects, and to develop new projects in high priority areas. To achieve this, it is essential that we maintain and build upon our current reservoir of research expertise.

Collaboration and consultation

While it is essential that we develop and expand our own expertise, our research will benefit through collaboration and consultation with other agencies possessing relevant skills and knowledge.

The Marine Fish Habitat Research Program will involve active collaboration with research agencies that possess skills and expertise to complement our own. This collaboration will effectively increase DPI's research output, enhance the quality of our research and assist in achieving our aims. Potential research collaborators include:
- Federal Government (e.g. CSIRO, AIMS, GBRMPA, CRCs)
- State Government (e.g. DNR, EPA, other sectors of DPI)
- Universities (e.g. UQ, GU, JCUNQ, USC, CQU, QUT)
- Other State and Territory fisheries research agencies.

The Marine Fish Habitat Research Program will also consult with client groups and other agencies relevant to fisheries and the marine environment. This consultation will contribute to setting research directions, enhance the relevance of our research and assist in promoting our aims. Agencies to be consulted include the above research collaborators and:
- the Queensland Fisheries Service (QFS)
- fishing industry (e.g. QSIA, Sunfish, fishing clubs)
- other industry (e.g. agricultural, infrastructure and maritime industries)
- funding agencies (e.g. FRDC, QFIRAC, NHT)
- local government (e.g. councils, QLGA)
- community groups (e.g. AMCS, URGQ, environmental groups).

Extension and publication

The links between habitat and fisheries production may be subtle and complex, yet it is essential that they be understood and appreciated by stakeholders. Such understanding and appreciation will lead to support from stakeholders for habitat protection and rehabilitation, and contribute to the sustainability of Queensland's fisheries resources. Thus it is important that results of fisheries habitat research projects be made available to stakeholders in readily accessible formats. Appropriate extension activities will be identified and budgeted for in each habitat research project. These will include use of mainstream and specialist media, production of specifically targeted brochures and web pages, condition and trend reporting, direct advice to management agencies and direct communication through field days and meetings.

Summaries of research findings will also be placed on the DPI Fishweb site.

Many of the questions that will be addressed by the Marine Fish Habitat Research Program are relevant to marine scientists and managers throughout the world. To ensure that the results of our research are widely disseminated, obtain peer review, and maintain and enhance DPI's scientific credibility, important results will be published in high-quality international scientific journals.

Funding

Funding for fish habitat research will be sought from a variety of internal and external sources. Internal funding of specific projects is appropriate for research projects that have been identified as being of the highest priority to DPI. Funding for fish habitat research should be an integral component of DPI's overall fisheries research budget.

External funding sources include competitive research grants for projects generated within DPI, and funds provided by outside agencies to conduct self-generated projects. As each agency has its own research agenda and priorities, such projects may or may not address DPI's priorities. Staff from the Marine Fish Habitat Research Program will liaise closely with fund providers to ensure that the research priorities of each partner are addressed and appropriate research projects are supported.

One major external source of funds is likely to be the Fisheries Research and Development Corporation (FRDC), through its Ecosystems Protection Program. As FRDC funding is limited and competitive, it will be necessary to seek further funding through agencies such as the Great Barrier Reef Marine Park Authority (GBRMPA), the National Heritage Trust (NHT), Cooperative Research Centres (CRCs), port authorities, government (local, state and federal) and other agencies. Close collaboration with university researchers will generate further funding opportunities through the Australian Research Council's Strategic Partnerships with Industry, Research and Training scheme (ARC SPIRT).

Themes

The Marine Fish Habitat Research Program will be based around six (6) themes. Each theme will address a core research question to achieve one of the primary goals outlined above. These themes are interdependent, so that information from each will contribute to achieving the objectives of other themes.

The six themes and their core research questions are:

1. Habitat Utilisation	What habitats are used by fish species and how are those habitats linked?
2. Habitat Status	What is the extent and condition of those fish habitats?
3. Habitat Production	What are the relationships between fish habitats and fisheries production and sustainability?
4. Ecological Processes	How do natural ecological processes influence the extent of available fish habitats and subsequent fisheries production and sustainability?
5. Human Impacts	What are the effects of human activities on fish habitats and their associated fisheries resources?
6. Habitat Rehabilitation	What are the effects of habitat rehabilitation and enhancement on fisheries resources?

Theme 1: Habitat Utilisation

What habitats are used by fish species and how are these linked?

Rationale

The most fundamental question in fish habitat research is 'what are the habitat requirements of fish species?' The life histories of most marine species are complex, typically involving planktonic larvae, juveniles that use specific habitats, and adults that usually use entirely different habitats. In addition to this 'critical chain of habitats' necessary to complete their development (Cappo et al. 1998), many marine species use different habitats in different seasons, or at different times of the solar, lunar or tidal cycles. Marine species need access to particular habitats at particular times, and the relative availability of those habitats may influence each species' production.

Objectives

1. To identify the habitats used by fish species at different times and life stages.
2. To identify links between habitats which influence habitat availability to fish species.

Strategies

Three complementary strategies will be used to determine the habitats used by fish species.
1. Species strategy. This follows the habitat utilisation of particular species (e.g., tracking the habitats used by snapper throughout its life cycle). The principle advantages of this strategy are that it:
   * can be easily incorporated into fisheries stock research, and
   * provides information on the linkages between different habitats.

2. Habitat strategy. This determines the species that use a particular habitat (e.g., sampling the species present within a particular mangrove stand). The principle advantages of this strategy are that it:
   * is methodologically simpler as it involves sampling a single habitat type, and
   * addresses the management need to know the roles of particular habitats.

3. Ecosystem strategy. This investigates habitat–species links within a particular ecosystem (e.g. habitat utilisation by fish species in Trinity Inlet). The principle advantage of this strategy is that it:
   * enables holistic understanding of the habitat–fisheries linkages within a particular system.

The Marine Fish Habitat Research Program will include all three of these strategies in a whole-of-ecosystem approach, to access the advantages of each. This will be achieved at the individual project level, by ensuring that:
   * fisheries stock research projects incorporate a habitat component;
   * habitat research projects are directly relevant to fisheries stocks; and
   * integrated fisheries — ecosystem research projects are conducted within specific areas.

Selection of appropriate species, habitats and ecosystems will involve close collaboration with researchers, managers, stakeholders and other agencies. This process will use a number of recent reviews of fish habitat research to identify current gaps in our research efforts (Cappo et al. 1998, Zeller 1998, Butler & Jernakoff 1999).

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Theme 2: Habitat Status

What is the status of fish habitats?

Rationale

Marine fisheries habitats exhibit a diverse range of physical, chemical and biological properties. These properties include the extent, location, structure and condition of the habitat, its water quality and the community of organisms that use that habitat. These properties affect the population sizes and production of species that use those habitats. Identifying and monitoring those properties will help to monitor the status and predict trends in Queensland's fisheries resources.

The Resource Condition and Trend Unit and the Marine Fish Habitat Unit currently address elements of this theme within the DPI Fisheries Group. The focus of the Resource Condition and Trend Unit has been on coastal habitats (particularly protected marine plants such as mangroves), and has involved a combination of remote sensing and 'ground-truthing'. The Marine Fish Habitat Unit has conducted a number of surveys of particular areas as part of the Fish Habitat Area declaration process, and is recognised internationally for its expertise in surveying and monitoring seagrasses. The Great Barrier Reef Marine Park Authority (GBRMPA) also sponsors and conducts surveys of benthic marine habitats in the Great Barrier Reef World Heritage Area. The Marine Fish Habitat Research Program will aim to integrate and extend the current activities of DPI, the Environment Protection Agency (EPA) and GBRMPA to provide a broader coverage of fish habitat types and areas. Effective monitoring of the extent and condition of Queensland's marine fish habitats will involve close liaison among the three management agencies.

Objectives

1. To prepare maps, inventories and GIS databases of the structure and extent of fish habitats identified under Theme 1.
2. To monitor changes in the status of those fish habitats over time.

Strategies

The Marine Fish Habitat Research Program will build upon the current strengths within the DPI Fisheries Group to develop a fully integrated program of marine fish habitat surveys and monitoring. Current activities will continue to be the responsibility of the relevant groups. Those activities will be supplemented by surveys and monitoring of habitats not currently investigated. Surveys and monitoring conducted under this theme will involve a combination of remote sensing and 'ground-truthing'. Activities will include:

- The adaptation of remote sensing technologies (e.g. aerial photography, satellite imagery, seabed classification) for assessment of fish habitats.
- The conduct of remote sensing of habitat types, with verification and improvement of the resolution through 'ground-truthing' (e.g. site visits, SCUBA diving, underwater video).
- Preparation of maps and inventories (e.g. CHRIS, GIS).
- Monitoring the changes in the status of fish habitats over time (condition and trends).
- Quantification of seasonal and long-term changes in the extent and condition of biotic habitats (seagrass, mangroves, algae, coral reefs).
- Quantification of long-term changes in the extent and condition of abiotic habitats (rock, sand, mud).
- Measurement of seasonal and long-term changes in water quality (and identification of indicators).

Theme 3: Habitat Production

What are the relationships between fish habitats and fisheries production?

Rationale

Particular habitats may be essential for the normal development of some species, while other species may be able to use a range of alternative habitats. The effects of different habitat types and properties on population sizes and production will vary depending upon each species requirements or preferences. By relating habitat resources to their associated fisheries resources, projects within this theme will provide a basis for determining just how important particular habitats are for particular fish species.

Correlating habitat status to fisheries production will be complicated by the many other factors that also influence fisheries. Uncertainty regarding the effects of those factors will mask the effects of changes in habitat status. For this reason, modelling of the potential effects of fluctuations in habitat properties will be conducted in conjunction with monitoring studies of habitat status and fisheries production. Such models cannot determine the effect of changes in habitat on fisheries production, but they can generate hypotheses that can subsequently be tested through experimentation. Such experiments will involve research into the effects of habitat loss or damage (Theme 5) and the effects of habitat enhancement or rehabilitation (Theme 6) on fisheries production.

Objectives

1. To correlate fluctuations in the extent, condition and accessibility of fish habitats with fisheries production.
2. To develop mechanistic models that may explain how fluctuations in habitat status might influence fisheries production.
3. To test those models empirically, including manipulative laboratory and field experimentation.
4. To determine the extent to which changes in fished populations can be predicted from known changes in habitats.

Strategies

Research into the relationships between fish habitats and fisheries production will involve integration of the other five themes. The initial stages of this research will involve identification of the resource utilisation of fished species (Theme 1) and determination of the extent and condition of fisheries habitats (Theme 2). It will then generate hypotheses regarding the relationships between fish habitats and fisheries production by:
- correlating natural changes in habitat status (extent, condition, availability) with measures of fisheries resources (fishery independent assessments, catch per effort);
- conducting laboratory experiments to determine the effects of differences in habitat type and quality on the behaviour, growth or survivorship of fished species;
- developing mathematical models to predict the effects of changes in habitat status on fisheries resource status; and
- developing economic models to predict the effects of those changes on fisheries production and the value of that production.

Those hypotheses will then be tested through experimental studies of the effects of human induced habitat changes, including loss or degradation (Theme 5) and enhancement or rehabilitation (Theme 6) on fisheries resources.

Theme 4: Ecological Processes

How do natural ecological processes influence the extent of available fish habitats and subsequent fisheries production and sustainability?

Rationale

Fish species are key components of natural aquatic ecosystems comprised of the physical environment within which fish live and the other organisms with which they interact. Fish influence, and are influenced by, other components of those ecosystems. Knowledge of the effects of interactions between fish and their biological and physical environment is essential for understanding natural fluctuations in fish populations and determining the effects that exploitation may have on non-target species or ecological processes. An understanding of natural fluctuations is also important in identifying the relative impacts of human activities (Theme 5).

Ecological processes which may influence fish populations include biological interactions (e.g. food supply, predation, competition) and physical effects (e.g. currents, water temperature, salinity, hydrological discharges). Fish habitats and their associated fish populations may also be affected by natural catastrophic events such as cyclones and floods.

Objectives

1. To understand the effects of natural physical processes on fish populations and fisheries production and sustainability.
2. To understand the effects of interactions with other species on fish populations.
3. To understand the roles of exploited or potentially exploited fish populations within natural ecosystems.
4. To determine the relative importance of various pathways of the energy and nutrients that support fish populations.

Strategies

1. Whole of ecosystem strategy. Understanding the roles of various ecological processes in marine systems where many factors may influence fish populations will require a coordinated approach using a suite of methods. In particular, it will require close collaboration with researchers in other fields such as oceanography, hydrology and nutrient dynamics. This would be best achieved through multi-disciplinary, multi-agency studies of particular ecosystems of direct significance to fisheries. Some examples of information that may be generated through such collaborative studies include the sources of nutrients for fish populations, the effects of freshwater flows on estuarine and coastal fish populations or the effects of oceanic currents on spawning migrations and fish recruitment. Larger-scale collaborative studies may also be used to investigate the effects of global environmental changes such as climate change.

2. Individual interaction strategy. Specific interactions of interest will be investigated through smaller-scale, more focussed projects. These projects would be conducted largely within the DPI Fisheries Institute, although they may also involve outside researchers or postgraduate students. Some examples of information that may be generated through this strategy include specific dietary studies or laboratory-based studies of the effects of changes in physical or chemical parameters on fish behaviour, growth or other biological parameters.

Theme 5: Human Impacts

What are the effects of human activities on fish habitats and their associated fisheries resources?

Rationale

Human activities may degrade, enhance or have little effect on fish habitats and their associated resources. Fisheries managers need precise, quantitative information about the effects of human activities in order to make well-supported policy decisions regarding those activities.

Human activities which may influence marine fish habitats and their associated fisheries resources include activities on land, in freshwater and in the sea. The effects of those activities may be complex and difficult to predict, and may interact with each other or with natural fluctuations. Some human activities may alter habitats in a way that degrades one resource while enhancing another. Human-induced effects may also be difficult to detect as each may have only a small incremental effect that may be masked or confounded by natural variability. Thus it is essential that research into the effects of human activities is conducted at an appropriate scale, examines appropriate variables and is based on sound experimental design.

Objective

1. To determine the effects of human activities on fish habitats and their associated fisheries resources.

Strategies

Research conducted under this theme will be closely integrated with Themes 3 and 4, and will aim to test predictions generated by correlative studies, laboratory experiments and modelling. This hypothesis-testing approach will be based around standard experimental designs for human impacts research. These include:
- Before and After, Control and Impact (BACI) designs (in which sampling is conducted both before and after a potential impact, at both control and impacted sites);
- Beyond BACI designs (= BACI designs that incorporate several control sites and multiple samples both before and after the potential impact);
- Multiple BACI designs (= beyond BACI designs that incorporate multiple impact as well as multiple control sites).

Specific human impacts that may affect fisheries production or sustainability, and that may be investigable using this approach include:
- fragmentation, loss or degradation of fish habitat;
- changes in water quality;
- obstructions to fish movement.

Theme 6: Habitat Rehabilitation

What are the effects of habitat rehabilitation and enhancement on fisheries resources?

Rationale

Mitigation of the potential adverse effects of habitat degradation may serve to enhance fisheries production. There is a need to establish protocols and procedures for optimal marine fish habitat rehabilitation, and to determine the effectiveness of rehabilitated habitats in supporting fisheries production. Fishing activities may also influence the habitats on which fisheries depend. Research into the effects of fishing on whole ecosystems is vital to ensure fisheries sustainability.

Objectives

1. To determine the effects of changes in environmental mangement on fish habitats and their associated fisheries resources.
2. To develop a process for determining the feasibility of rehabilitation proposals.
3. To determine optimal methods for rehabilitating fisheries habitats which have been lost or degraded through human activities.
4. To monitor the development of rehabilitated habitats over time.

Strategies

Research into the effects of fish habitat enhancement or rehabilitation will use the same methodologies as research into human impacts, only the expected outcome would be beneficial to fisheries resources rather than detrimental. As for Theme 4, research under this theme will also relate to hypotheses developed in Theme 3. The same broad categories of experimental design will be employed to investigate the effectiveness of habitat enhancement and rehabilitation projects.

Specific types of human impacts that may be investigable using this approach include:
- effects of Marine Protected Areas (MPAs, e.g. 'no-take' reserves, Fish Habitat Areas) on the status of fisheries resources;
- effects of habitat rehabilitation projects (e.g. beach replenishment, revegetation) on fisheries resources;
- effects of habitat enhancement projects (e.g. vegetating previously unvegetated areas, creation of artificial reefs) on fisheries resources.

Bibliography

Butler, A.J. & Jernakoff, P. (eds), 1999. Seagrass in Australia: strategic review and development of an
   R & D plan. Fisheries Research and Development Corporation project #98/223, CSIRO Publishing,
   Melbourne. 210 pp.

Cappo, M., Alongi, D.M., Williams, D.McB. & Duke N., 1998. A review and synthesis of Australian fisheries
   habitat research: major threats, issues and gaps in knowledge of coastal and marine fisheries habitats.
   Fisheries Research and Development Corporation project #95/055, Australian Institute of Marine Science,
   Townsville. Volumes 1–3, 633 pp.

Zeller, B., 1998. Queensland's fisheries habitats: current condition and recent trends.
   Department of Primary Industries, Queensland, Brisbane. 211 pp.

Abbreviations

AIMS	Australian Institute of Marine Science
AMCS	Australian Marine Conservation Society
ANOVA	Analysis of Variance
ARC SPIRT	Australian Research Council—Strategic Partnerships with Industry, Research and Training scheme
BACI	Before and After, Control and Impact experimental design
CHRIS	Coastal Habitat Resource Information System
CQU	Central Queensland University
CRCs	Cooperative Research Centres (e.g. CRC for Coastal Zone, Estuary and Waterway Management; CRC for the Great Barrier Reef World Heritage Area; CRC for Sustainable Sugar Production)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNR	Department of Natural Resources (Queensland Government)
DPI	Department of Primary Industries (Queensland Government)
EPA	Environmental Protection Agency (Queensland Government)
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
GIS	Geographical Information System
GU	Griffith University
JCUNQ	James Cook University of North Queensland
MPA	Marine Protected Area
NHT	National Heritage Trust
QFS	Queensland Fisheries Service
QLGA	Queensland Local Government Association
QSIA	Queensland Seafood Industry Association
QUT	Queensland University of Technology
SCUBA	Self Contained Underwater Breathing Apparatus
URGQ	Underwater Research Group of Queensland
USC	University of the Sunshine Coast
UQ	The University of Queensland

Acknowledgments

Marine Fish Habitat Research

STRATEGIC PLAN

Fishing is an integral part of the Queensland economy and way of life. As well as being the State's fifth largest primary industry, fishing is a major recreational activity and an important part of indigenous cultures.

Queensland's marine fisheries are extremely diverse, involving over 100 species of fish, crustaceans, molluscs, worms and other animals. Effective management of such diverse fisheries requires an understanding of the entire marine ecosystem, including the roles of essential fish habitats (e.g. coral reefs, rocky reefs, mangroves, seagrasses and mud flats).

This document outlines a whole of ecosystem approach to fisheries research that will support the sustainable development of our fisheries while maintaining the health of our marine ecosystems.

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