

Northern Prawn Fishery



Five year Research Plan 2001 - 2006



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Report prepared by the

NORMAC Research and Environment Subcommittee

February 2001





Introduction

The Northern Prawn Fishery (NPF) is the most valuable Commonwealth managed fishery with the value of the catch over recent years varying around A\$120 million. Total catch in 1999 was 6,947 t caught by a fleet of 129 vessels. The Fishery extends from Cape Londonderry in Western Australia to Cape York in Queensland. It started in the late 1960s and is a multi-species fishery targeting prawns. The NPF is generally partitioned into two fisheries: the daytime fishery for banana prawns and the night-time fishery for tiger prawns, each fishery providing about half of the total NPF catch.

Incidental catches of other commercial species of prawns, other crustaceans, squid and some fish are taken in both the banana prawn and the tiger prawn fisheries (by-product). Trawlers in the NPF also catch large amounts of animals other than prawns and by-product that has no commercial value (by-catch). Trawls passing over them may also affect some seabed animals that are not retained in the nets (non-retained bycatch). The fishery is characterised by being highly innovative, readily adopts new technologies and rapidly responds to issues affecting the fishery.



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Research is an integral part of the management of the Northern Prawn Fishery. The managers of this fishery have a long history of incorporating research results into management decisions. Part of this process is ensuring that research is relevant to the fishery. There are three important ways in which this is achieved.

- 1 NORMAC has a set of Research Priority Areas that are reviewed annually. These Priority Areas provide a guide to researchers of the needs of the fishery.
- 2 The NORMAC Research and Environment Subcommittee (REC) annually reviews research proposals for the major funding bodies and assesses them against NORMAC's priority areas.

- 3 In addition to an annual research levy of \$250,00 contributed to FRDC, NORMAC contributes directly to certain projects in order to fill gaps that might otherwise occur in funding.

Through the provision of accurate logbook and other fisheries information, NPF industry makes it possible to carry out high level research into the fishery that would otherwise not be possible.

In the evaluation of research priorities for the NPF and the production of the 5 Year Research Plan, NORMAC takes into consideration the objectives of the *Fisheries Administration Act 1991*, *Fisheries Management Act 1991* and the Northern Prawn Fishery Strategic Plan 2001-2006. The Committee also takes into consideration other relevant government policies and their implications for the management of, and research into, the fishery. Relevant government policies include the:

- Oceans Policy;
- Commonwealth Policy on Fisheries Bycatch 2000;
- Turtle Recovery Plan; and
- Relevant Commonwealth and State Environmental Legislation, e.g. Environment Australia's sustainability criteria for fisheries that will guide the strategic assessment of the fishery required with the introduction of the *Environment Protection and Biodiversity Conservation Act 1999* and changes to Schedule 4 of the *Wildlife Protection (Regulation of Export and Imports) Act 1982*.

This is the third Research Plan produced by NORMAC for the Northern Prawn Fishery. The first plan appeared in 1997. The present plan covers the five financial years from 1997/98 to 2000/01.



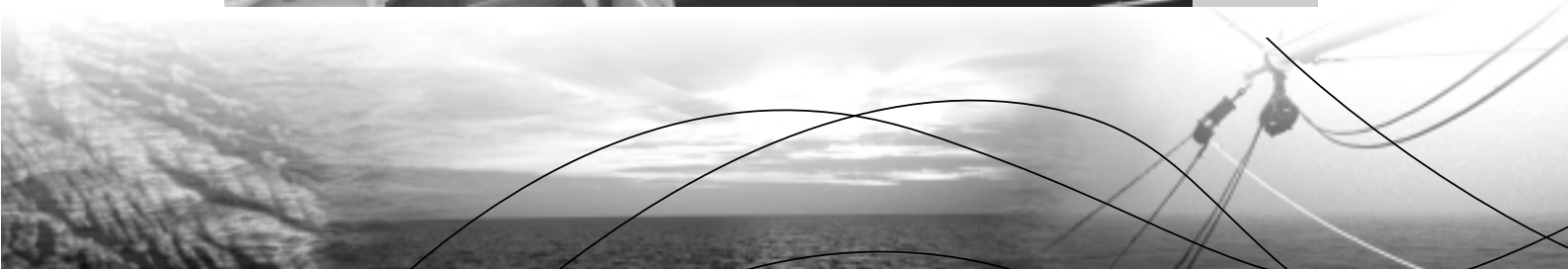
NORMAC Research and Environment Sub-committee: Terms of Reference

The terms of reference of NORMAC Research and Environment Sub-committee are to:

- 1 advise NORMAC on research and environmental matters concerning the Northern Prawn Fishery (NPF);
- 2 advise NORMAC on priorities for research needed in the NPF;
- 3 assess research proposals dealing with the NPF and provide advice to AFMA on research proposals to the AFMA Research Fund and to FRDC;
- 4 prepare a Five Year Research Plan for the NPF. This plan is to be updated annually and to include a summary of results from research under way in the NPF;
- 5 provide advice to NORMAC on potential environmental threats to the NPF from developments such as mining and port development, and changes in land-use;
- 6 provide advice to NORMAC on ESD issues; and
- 7 encourage research in the NPF by making research providers aware of NORMAC's research priorities.

The current members of the NORMAC REC and their contact details are listed in Appendix 2.

The Chair of the NORMAC Fishery Assessment Group (FAG), also attends NORMAC REC meetings to provide information about the FAG's research priorities to improve the stock assessment process.



Research Priority Areas for the NPF 2001/02

In February 2001, NORMAC agreed to the following research priority areas for the Northern Prawn Fishery for 2001/02. These priorities should be taken into account by researchers planning to develop applications for research funding from AFMA, FRRF and FRDC and other funding agencies in 2001. NORMAC is currently undertaking a strategic review of the NPF as part of the development of a 10-year strategic plan for the NPF. The review is addressing 5 broad categories of issues for inclusion in the new strategic plan being research, environment, management, native title and stakeholder consultation. The review includes extensive consultation with industry and other stakeholders and will be completed by 2001 to allow NORMAC to finalise the new strategic plan and report to AFMA. The process included a February 2001 workshop that identified research needs for the next five years. The list of research priority areas that resulted from this workshop were incorporated in the NPF research plan and circulated to research providers in April 2001 (Table1).

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Table 1. Research Priorities for the Northern Prawn Fishery 2001/02.

Priority	Research Area	Topics included
High	Assessment of the status of the fishery including management strategies for the fishery (target and byproduct species)	Stock assessment techniques including management strategy evaluation and reference points; catch and effort analysis; effect of new technologies on fishing power; stock recruitment relationships of prawns; yield per recruit modelling; economic analysis of the performance of the fishery including economic efficiency indicators, socio-economic impacts of changes in management regimes; collection of information for the management of resources such as squid, bugs and scallops
High	Effects of fishing; improved efficiency in fishing gear and techniques in order to reduce bycatch and discarding, increased survivorship of bycatch and environmental impacts on the benthos	Assessment of bycatch; effects of trawling on the seabed; sustainability of bycatch species; effects of discarding; development and improvement of bycatch reduction devices; development of monitoring programs for BRDs under commercial conditions; development of alternate fishing practices; increased survival of bycatch
High	Improved knowledge of environmental factors of importance to the fishery	Relationships between spawning areas and recruitment; studies of the nursery habitats of prawns; monitoring of state of critical habitats; establishment of marine protected areas (MPAs); background studies of heavy metals in prawns; effect of the environment on prawns; assessing the impact of fishery closure areas and MPAs for conservation
Medium	Improved efficiencies in the economics of fishing	Development of more fuel efficient technologies; improved trawler design
Medium	Utilisation of bycatch species	New byproduct species
Low	Post harvest technology and harvesting	Improved catch handling systems; improvement of product quality
Low	Enhancement of the resource	Stock enhancement; reseedling





Expenditure on Research in 1997 – 2001

Research projects are usually funded from several sources. The most important source for research in the NPF is the Fisheries Research and Development Corporation (FRDC). Research agencies, especially CSIRO Marine Research, also spend large amounts of their own research funds in the NPF. Each year NPF industry contributes between \$250 000 and \$300 000 to FRDC. This is a compulsory levy estimated as 0.25% of the gross value of production of the fishery. In addition, NPF industry contributes significant funds to support special projects that fall outside of the normal funding cycle. These are known as Management Initiated Research Funds (MIRF). Funds are also available from other sources: the AFMA Research Fund (ARF) and the Fisheries Resources Research Fund (FRRF) as well as the various research agencies. The NPF also gains from research carried out in other fisheries where the results are applicable to the NPF. An example is the effects of fishing research carried out on the east coast. Results of this research considerably shorten the time needed to develop bycatch reduction options.

A summary of the funds expended from the main sources on the NPF is shown in Table 2. The figures have been adjusted to reflect the attribution to the NPF. Figures for 2000/01 and especially for 2001/02 will probably be increased by additional projects being approved after the date of this compilation. Other FRDC funded research projects attribute some small part of their benefits to the NPF— these have not been included.

There has been a gradual reduction in the funds expended in the NPF by large contributors such as FRDC and CSIRO as well as smaller players such as AMC and QDPI. Although there has been an increase in spending by NPF industry, the overall funds spent in the NPF have declined. In February 2001, NORMAC agreed to increase the NPF contribution to FRDC by \$100 000 conditional on reaching agreement with FRDC on a guaranteed minimum return on the contribution and an efficient project approval process.



Table 2. Sources of research funding (\$1000s and %) for the Northern Prawn Fishery

	1997/98 \$1000s %	1998/99 \$1000s %	1999/00 \$1000s %	2000/01 \$1000s %	2001/02 \$1000s %	Total \$1000s %
FRDC ¹	907 42	731 38	541 29	377 20	584 29	3140 32
CSIRO	772 36	700 36	352 19	301 16	455 22	2580 26
NPF Industry ²	302 14	297 15	460 25	408 22	352 17	1818 19
AFMA RF ³	72 3	53 3	43 2	67 4	20 1	254 3
AMC	0 0	0 0	87 5	68 4	49 2	204 2
QDPI	39 2	72 4	153 8	258 14	174 9	696 7
FRRF	60 3	65 3	15 1	15 1	54 3	209 2
Other ⁴	0 0	11 1	203 11	350 19	342 17	906 9
Total	2150 100	1928 100	1853 100	1845 100	2029 100	9806 100

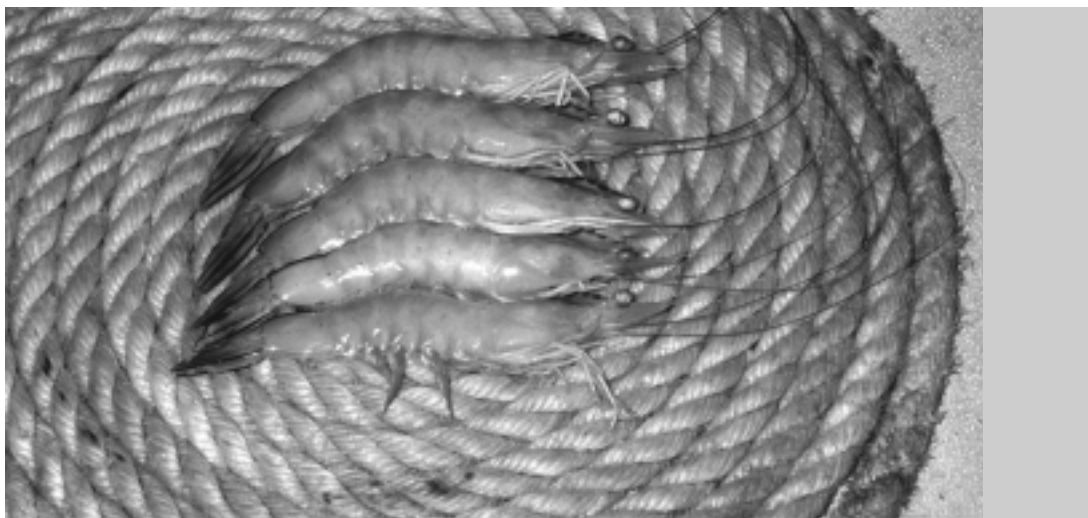
Notes:

¹The FRDC contribution from 2000/01 does not include the NPF Industry contribution (eg \$281,000 in 2000/01) which is included in the NPF Industry category

²The contribution by NPF Industry for 2001/02 is an estimate based on the previous year.

³From 2000/01 the AFMA RF includes the stock assessment costs of the NPF FAG

⁴The category "Other" includes the following agencies: AIMS, BRS, ABARE, APPA, CSIRO Livestock Industries, Curtin University, Fisheries Department of Western Australia, MG Kailis Group of Companies, Great Barrier Reef CRC, Environment Australia and the University of Tasmania



Expenditure relative to Research Priorities

A comparison of expenditure of research funds identified in Table 2 with the NORMAC research priorities shown in Table 1 can be used as an indicator of how well research expenditure is aligned with NORMAC priorities. To do this, all projects completed or underway have been allocated by the NORMAC Research and Environment Subcommittee into the various research priority areas identified by NORMAC. The funding for each project was then apportioned to each priority area according to the allocation. The outcome is given in the following Table.

Table 3. Proportion of research funds spent in each of the six Priority Areas for Research in the Northern Prawn Fishery in 2000/01

Priority	Research Area	Percentage of funds expended
High	Assessment of the status of the fishery including management strategies for the fishery	44%
High	Effects of fishing; improved efficiency in fishing gear and techniques in order to reduce bycatch and discarding and environmental impacts on the benthos	36%
High	Improved knowledge of environmental factors of importance to the fishery	10%
Medium	Improved efficiencies in the economics of fishing	13%
Medium	Use of alternative resources	1%
Low	Post harvest technology and harvesting	3%
Low	Enhancement of the resource	3%

Table 3 shows that most research funding has addressed High Priority Research items. The allocation within the three High Priority areas is somewhat skewed with environmental factors receiving only 10%, whereas the other two areas each received more than twice this proportion. Medium and Low Priority areas receive very little funding. NORMAC needs to decide whether this allocation is satisfactory or if a different emphasis needs to be adopted when considering research proposals in order to prevent neglect of some medium and low priority areas.





Summaries of NPF Research projects completed since 1997

Note: The name of the Principal Investigator is given first and is used for arranging the summaries in alphabetical order. The years refer to the starting and finishing dates. Agencies contributing to the funding of the project are listed. Dollar amounts are only those attributed to NPF and are not necessarily the total cost of the project. In some cases it was not feasible to identify the NPF share of the cost of the project.

ABARE

Applying ESD principles in the Northern Prawn Fishery: an economic assessment

ABARE, FRRF (Cost not available)

2000.

Summary

Implications of alternate management instruments for the sustainability of target stocks, the commercial fishery and the marine environment were examined in this report. The sustainable management of the marine environment is discussed, with consideration of the impacts that management of the commercial fishery may have on the marine environment. The sustainability of the principal commercial prawn species is examined in the light of alternative measures to control fishing efforts. The feasibility of monitoring and adjusting fishing restriction in real time in response to the observed state of stocks is also investigated. Where appropriate, moving images showing the temporal and spatial pattern of fishing are used to assess the likely effects of different management options.

Bishop J, Sterling D

Survey of Technology utilised in the Northern Prawn Fishery

CSIRO, DJ Sterling Trawl services, NPF industry, AFMA Research Fund (\$14 000)

1998-1999

Summary

The survey aimed to establish a sound basis for tracking of changes in fishing power in the Northern Prawn Fishery by collecting data on key aspects of configuration of all vessels in the Northern Prawn Fishery. As vessels are reconfigured, or a fleet adopts new technology, changes in fishing efficiency follow.



Methods: All owners of statutory fishing rights in the NPF were requested to take part, and interviews were completed with representatives of 92% of the fleet of 1998. Half (55%) of the interviews were with single boat owners, a third (34%) were with owners of 3 or 4 boats, and the remaining 10% were with representatives of companies with more than 10 boats. Most (78%) of those interviewed were owners or managers, and the other 12% were skippers or fleet engineers. A third (31%) of the interviews were conducted on board, and the remainder were conducted in an office or elsewhere.

Opinions about the importance of some factors in relation to fishing performance: Try nets, plotters and echo sounders were rated as the having the greatest impact on fishing performance, followed by engine power, communication equipment and GPS error. Otter board size, net size and vessel dimensions were rated as having some impact, while radar and stabilisers were rated as having low impact.

Engineering performance of the vessel: Median rated engine power in the fleet was 300kw (interquartile [iq] range 272-336). According to the opinions of interviewees, over a third of the surveyed vessels (38%) had motors that could potentially produce more power than stated on the SFR register, (iq range 45-100 kW more). Median prop diameter was 1.52 m (iq range 1.5-1.7). Bollard pull (the maximum thrust capability of a vessel while held stationary) was estimated by a deterministic engineering prediction model (Prawn Trawl Performance Prediction Model, (PTPPM, Sterling DJ 1996) for a subset of the vessels from rated power, reported propeller diameter, maximum trawling rpm, operating trawling rpm, and rated rpm. Median estimated bollard pull in the fleet was 5523 kg wt (iq range 5023-6312).

Characteristics of fishing gear that affect fishing efficiency: Median twine thickness was 36 ply (iq range 30-36); knotless netting was currently used in 7% of tiger prawn nets and none of banana prawn nets and none used spectra netting; Bison no 9 were the most common boards; median headrope length was 28 fathoms (iq range 24-28); and most common body taper was 1P4B (reported by 49% of vessels. Swept area performance was calculated for a subset of vessels by the PTPPM based on trawl gear specifications, calculated bollard pull. Assuming a tiger prawn fishing night was 12 hours, and each vessel fished for tiger prawns for 138 nights in 1998), the median swept area per vessel per night was 2.3 square kilometres (iq range 2.0-2.5) and the median swept area per vessel for the year in 1998 was 319 square kilometres (iq range 281-341). Note that these estimates of swept area do not take into account any degree of re-trawling over the same grounds.

Innovations with potential to improve catch efficiency of the trawl design include groundgear type (all had Texas); Stainless steel groundline (used on 88% of vessels); square mesh codend (no vessels); codend mesh size (median 50mm, iq range 47.6-50.8). Information relevant to bycatch reduction was also collected.

Innovations with potential to improve targeting ability of the vessel and crew and possibly trawling time include differential GPS (currently 65% of vessels with active DGPS mode), automated trawl gear (on board 3% of vessels); communications improvements (currently satellite phone 97%; personal Computer linked to email facilities 42%). The most common plotter type was non-PC based (Furuno or JRC, 75%); autopilot was linked to GPS on board 19% of vessels.

References and further information:

Sterling D 1996 "Abridged Description and Performance Appraisal of Australian Prawn Trawl Systems" AMECRC (Perth Node) Report, DJ Sterling Trawl Gear Services Brisbane.

Bishop J and Sterling D."Measuring Effort Creep in the Northern Prawn Fishery", 1999 NPF Preseason Forum, Cairns 1999.

Bishop J. & Sterling D. 1999. Survey of technology utilisation in the NPF fleet. (AFMA, Canberra, Aus).

Caton A, McLoughlin K, Staples D (Editors)
Fishery Status Reports 1997
BRS (Cost for NPF has not been separated out)
1997

General Note

The Bureau of Rural Sciences' annual 'Fisheries Status Reports' form part of an independent assessment of AFMA's management performance in relation to that Authority's resource status objective. The reports review the status of the stocks supporting the major Commonwealth fisheries, based on the most recent assessments carried out by a range of research agencies, including State agencies and the CSIRO. Additionally, special focus chapters address topical issues. In the 1999 edition there are reviews on State/territory-managed fisheries (including a set of quick reference tables on about 100 of the main Australian commercial species), on Australian aquaculture, on environmental issues associated with fisheries, and on the ESD objective of Commonwealth fisheries management.

Points specific to the NPF

- The Northern Prawn Fishery is the most valuable fishery managed by the Commonwealth, the value of the annual catch varies around \$100-150 million
- The white banana prawn, the brown tiger prawn and the grooved tiger prawn comprise about 80% of the total catch
- Total catch for the fishery in 1996 was approximately 7700 t, compared with more than 10 000 t in 1995. Banana prawn catch was about 20% lower and tiger prawn catch declined by about 45%. Endeavour prawn catch was at its highest since the mid 1980s.



- Recent assessment of tiger prawn status suggests that current fishing effort is close to the level that should produce the estimated maximum sustainable yield for the two tiger prawn species. However, current landings are well below predicted sustainable levels and further investigation of the possible reason for this is a high priority.

Dichmont C, Bishop J and other members of the Northern Prawn Fishery Assessment Group
 Status of Tiger prawn stocks at the end of 1999
 CSIRO, AFMA (\$41 700)
 2000

Note

Stock assessment reports are produced annually, the following summary is only for 1999

Summary

Nominal fishing effort directed to tiger prawns during the 1999 fishing season decreased by 5,240 fishing days in comparison to 1998 mainly due to an extended seasonal closure in 1999. As a result of this, during 1999, effective fishing effort decreased by 15% on grooved tiger prawns and by 40% on brown tiger prawns with respect to 1998. Effective catch-per-unit of effort for both species declined between 1998 and 1999 and was well below the average of the last 7 years.

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According to the assessment carried out with the model of Wang and Die (1996), the recruitment of brown and grooved tiger prawns in 1999 declined by 9% and 11% respectively from 1998. The spawning stock present in late 1998 early 1999 decreased by 2.5% for brown tiger but increased by 26% for grooved tiger prawns from the previous year.

The estimates of Maximum Sustainable Yield (MSY), Spawning stock which produces maximum yields (S_{MSY}) and fishing effort which produces maximum yields (E_{MSY}) have slightly changed from those estimated over the last few years. The estimates of MSY for the period 1970-1998 are therefore 1800 t (as opposed to 1900t for previous years assessments) for brown tigers prawns and 1900 t for grooved tiger prawns. The associated E_{MSY} are respectively 6,999 (7150 in 1998) and 10,428 (9,660 in 1998) standard boat-days.

Effective fishing effort in 1999 was 18% below E_{MSY} for brown tiger prawns and 7% above E_{MSY} for grooved tiger prawns. Therefore, for all tiger prawns, the 1999 effective fishing effort was 3% below E_{MSY} . The main reasons for this decrease in effort were the time closure and movement of effort to the banana and other fisheries.

In late 1998 early 1999 brown tiger spawning stocks were 63% of the S_{MSY} and grooved tiger prawns were 82% of the S_{MSY} , therefore spawning stocks remain below the levels that will produce MSY.



In conclusion:

- 1 Spawning stock levels for both tiger prawn species as at the end of 1999 are below the target levels of S_{MSY} (brown tiger 63% and grooved tiger 82% of S_{MSY}).
- 2 Both tiger species stocks remain over-exploited as at the end of 1999 and any rebuilding of spawning stocks to S_{MSY} requires effort levels of EMS_{Y} or less along with average recruitment. The lower the level of effort, the faster rebuilding will occur.

The reduction of effort in 1999 is due to the extended temporal closure and other factors.

Die D, Loneragan N, Haywood M, Vance D, Manson F, Taylor B, Bishop J
Indices of recruitment and effective spawning for tiger prawns stocks in the Northern Prawn Fishery
CSIRO, FRDC (\$972 283)
1995-1998

Non Technical Summary

In the mid to late 1980s NORMAC began to suspect that tiger prawn spawning stocks in the NPF may have been reduced by fishing to levels that reduced recruitment to the fishery. A vessel buy-back scheme and other effort reductions were introduced to reverse this trend but by the mid-1990s, the desired recovery of tiger prawns had not occurred. To understand the reasons for this, and with the support of FRDC, CSIRO began a 3-year research project in 1995 to improve our understanding of the relationship between the spawning stock and recruitment in the tiger prawn fishery. This report presents the results of this project.

This project has relied heavily on data gathered by the NPF fleet. Some of the data is provided to AFMA as a condition of the NPF permit (logbook data), but other data were provided to us voluntarily by fishers (GPS plotter disks with maps of the fishing grounds and the fisher's trawl tracks). Several fishers also took us on board their vessels to collect information on trawl catches and plotter tracks. We have shown how valuable these data are and how much is to be gained by enlisting the cooperation of the fleet.

One of the main research issues addressed by this project was to understand the spatial dynamics of tiger prawn stocks and the fleet that fishes them. We first developed electronic maps of fishing grounds using data from fishers' GPS-plotter systems. These maps identify the areas where trawling occurs and the areas where the substrate is such that trawling cannot occur (untrawlable areas). These maps have a resolution of 0.2 km - much finer than the 10.8 km scale provided by the logbooks. Fishing effort and the untrawlable grounds are distributed unevenly throughout the NPF. Some areas within fished logbook grids are intensively fished whereas others are untrawlable. The fishers tend to search for aggregations of tiger prawns early in the night. Once an area of higher catch has been located the vessel targets that same area for the remainder of the night. As a result,



some of the fishing ground is trawled several times in the same night but nearby areas may not be trawled. This information is essential for understanding seasonal and historical changes in the efficiency of trawling

In the past, population indices of spawning stock and recruitment for tiger prawn stocks were assumed to represent the entire NPF stock. However, given the geographical extent of the NPF, it is unlikely that adult prawns would mix thoroughly through the whole area. It was unclear, however, whether water circulation could contribute to the mixing of tiger prawn larvae. To address this question a simulation model of the currents in the Gulf of Carpentaria and the behaviour of larval prawns was developed. The model was used to predict the offshore spawning regions from which larvae could be expected to reach the seagrass nursery areas along the coast. The model shows that there are large gaps between these effective spawning areas and this suggests limited mixing of tiger prawn larvae within the Gulf of Carpentaria.

On a large scale, we have used logbook data to examine trends in the spatial extent of the fishery. Although the total area fished has been decreasing since 1983, the area searched continued to increase until 1987. Areas of high catch have remained unchanged throughout the history of the fishery. The area currently fished has contributed to the majority of the historical catches, but in the early 1980s only 60% of the total catch came from this area. Some areas that were fished in the 1980s are not fished today - some because they are now inside trawl closures, but others because of low catch rates. Commercial count data provided by skippers in their logbooks is accurate and was used to identify the location and seasonal pattern of recruitment of small prawns onto the fishing grounds. Many of the areas located as recruitment areas are on the edges of current area closures, supporting the hypothesis that these closures are protecting pre-recruits from harvesting. The analyses suggest that October/November tiger prawn catch rates of the 20-30 count category may be a good predictor of recruitment of tiger prawns in the following fishing season.

The analyses of logbook, plotter and larval advection data have led us to propose a new stock structure for tiger prawns inside the Gulf of Carpentaria. Seven new stock areas have been defined: some contain a stock of both grooved and brown tiger prawns, and others contain a stock of only one of these species. It is likely that other stock areas occur outside the Gulf of Carpentaria.

Spawning/stock recruitment relationships (SRR) have been defined at two spatial scales; firstly at an NPF-wide scale and secondly at each of the regional stock levels of the Gulf of Carpentaria. At the NPF-wide scale, the model suggests a strong influence of spawning stock on recruitment, and also increased recruitment, independent of the spawning stock, every 3 to 4 years. At regional scales the influence of spawning on recruitment is less apparent. However, simple biomass dynamic models suggest that, from 1993 to 1998, tiger prawn stocks in the Gulf of Carpentaria remained below the levels required to produce maximum sustainable yield, thus implying that these stocks were overfished. Similarly, standardised fishing effort for that same period remains above the fishing effort required to achieve maximum sustainable yield, thus implying that overfishing continued to occur.



Spatial analysis suggests that there are differences in the levels of overfishing between regional stocks. The assessments seem to confirm the perceptions of some members of the fishing industry who have suggested that the tiger prawn stocks in the Groote Eylandt region have not recovered from the overfishing that occurred in the early 1980s. They also suggest that the stocks in the Vanderlin and Mornington Island areas were further depleted during the later 1980s as the fishing fleet fished more in these areas in response to the depletion of the stocks around Groote Eylandt.

At smaller spatial scales our research has shown that fishing is highly aggregated. This reflects differences in the abundance of prawns and the type of bottom present within the fishing grounds. We believe that this knowledge will be critical in supporting the establishment of marine protected areas in northern Australia. To make this information more useful, however, we will need to quantify fishing impacts on prawn populations and benthic habitat at these small scales. This will require further research to characterise the reasons for these aggregations and the relationship between bottom type and benthic habitat.

In summary, this project has confirmed that tiger prawn stocks remain overfished at both a large (NPF-wide) scale and a regional scale. This implies that for NORMAC to put in place management measures that will recover the stocks from their overfished state, these measures will have to be effective in all regions of the fishery.

Holland P, Goodday P, Shafron W, Ha W, Lim-Applegate H

Australian Fisheries Surveys Report 1999: Northern prawn fishery survey results (note that the Report includes other Commonwealth Fisheries)

ABARE (Cost not available)

1998-1999

Summary

- Following higher per unit prawn prices in 1997-98, average receipts per boat across the fishery increased by almost \$170 000 in 1997-98 to over \$1.1 million per boat
- Costs per boat are estimated to have increased by 6% across the fishery in 1997-98. Cost increases were heaviest for boats with less than 375 A statutory fishing rights
- Estimated average boat business profit across the fleet increased to \$256 300 in 1997-98 from just under \$135 000 in 1996-97
- Average debt across the fishery is estimated to have declined slightly in 1997-98 to \$416 000 per boat. The boat business equity ratio for 1997-98 was 87 per cent.
- Net returns to the fishery (excluding any changes to stocks) rose from an estimated \$14 million in 1996-97 to around \$30 million in 1997-98



Johnson A, Cowell S, Loneragan N, Dews G, Poiner I

Sustainable development of Tropical Australia: R&D for Management of Land,
Water and Marine Resources

CSIRO, LWRRDC, FRDC (\$16 148)

1998

Land and Water Resources Research and Development Corporation published a full report as LWRRDC Occasional Paper 05/99. Only the objectives of the study are given here.

Objectives

- Undertake a data and information review that:
 1. develops a metadatabase for available regional data
 2. determines information needed to support management
 3. outlines planned development(s)
 4. summarises current legislative, jurisdictional and institutional boundaries documenting the scales of management needed
 5. summarise existing planning processes
 6. identifies the key aquatic resources and key attachment areas
- Document the activities, skills and resources of the research providers
- Consider the spatial extent of a potential study(s)
- Develop research proposal(s) aimed at supporting the sustainable development of land, water and marine resources in tropical Australia
- Consider ways of approaching an integrated multidisciplinary study(s) and identify potential obstacles and risks to research projects.

Loneragan N, Die D, Kailis G, Watson R, Preston N

Developing and assessing techniques for enhancing tropical Australian prawn fisheries and the feasibility of enhancing the brown tiger prawn (*Penaeus esculentus*) fishery in Exmouth Gulf

CSIRO, MG Kailis Company, FRDC (\$6 943)

1998-1999 (Stage 1)

Non-Technical Summary

The prawn trawl fishery in Exmouth Gulf, Western Australia, harvests a mixture of penaeid prawns. Catches of the high value, brown tiger prawn *Penaeus esculentus* comprised about 36% of the



annual catch in the 1990s. However, annual catches of tiger prawns are now about half the level they were in the 1970s and fluctuate markedly, from about 200 to 680 t. These changes in catch create uncertainty in the supply of prawns for export markets and force fishing and processing operators to have excess capacity to deal with good years. Managers, fishing industry and researchers are considering the option of enhancing the natural recruitment of brown tiger prawns by releasing juveniles in wild nursery areas to reduce natural fluctuations and increase the average annual catch.

This collaborative project (CSIRO, Fisheries WA, MG Kailis Group of Companies) assessed the feasibility of stock enhancement of tiger prawns in Exmouth Gulf by:

- developing a bioeconomic model
- examining the risks of changes in the genetic composition and introducing disease to the wild population of tiger prawns, and
- identifying further work that would be needed before stock enhancement should proceed.

This is the first of several stages that may lead to stock enhancement of tiger prawns in Exmouth Gulf. The project was initiated through a workshop of all project participants in Perth in July 1998.

Bioeconomic model

A bioeconomic model was developed in EXCEL to make it accessible to managers and industry. This model contains independent modules (linked worksheets) for the hatchery, production, nursery and fishery. The results from the model suggest that a release of 7 million juvenile prawns (1g) would increase catches of brown tiger prawns by about 100 t and that the median marginal revenue for this level of enhancement would be \$1.2M (range = \$0.8M to \$1.7M). The marginal revenue was affected mainly by variation in prawn prices and secondarily by the densities used to grow juvenile prawns. The variation in prawn prices should be considered a risk in any future enhancement project. The uncertainty about the best densities for producing juvenile prawns and the production environment (i.e. ponds or raceways) is an important area for future research and development. A further source of uncertainty in the model is the survival rates of prawns and how they vary at different stages of the enhancement (e.g. survival during transport and release, whether survival is density-dependent in the nursery).

The median difference between production costs and the median marginal revenue was about \$540, 000. This cannot be interpreted as strict profit because the model did not include all capital costs and because it used some assumptions that may not be realistic (e.g. 100% survival of juveniles during harvest and release). Sensitivity analysis showed that provided the mortality associated with the harvest, transport and release of juvenile prawns is less than 30%, the enhancement has a greater than 90% chance of still being profitable. Although the model did not include the costs of monitoring, the current results indicate how much can be spent on capital and



monitoring for enhancement to be profitable. The predictions of the current model therefore represent “best-case” scenarios for stock enhancement and would be refined, as new information becomes available. The model also provides a rigorous framework for evaluating the possible success of other enhancement projects.

Nursery habitats

Participants at the stock enhancement workshop recognised that little was known about the nursery habitats of brown tiger prawns in Exmouth Gulf, the dynamics of juvenile prawns in the nurseries, and predation rates on them. This information is needed to develop the best release strategies to ensure the success of a stock enhancement.

Risks of affecting the gene pool and introducing disease through stock enhancement

The risks of affecting the genetic composition of the wild stocks from the stock enhancement of penaeid prawns were discussed by a panel of industry representatives, research scientists, research managers and policy managers at the FRDC sponsored workshop on “Genetics in the Aquaculture Industry” held in Perth in October 1998. In this case the risks were considered low and recommendations were made for minimising the genetic risks. These were:

- Determine the genetic structure of the wild population prior to stock-enhancement
- Use broodstock only from the target population selected for enhancement
- Randomly collect broodstock (to avoid family groups)
- Trace individual families through rearing using genetic markers
- Release the same number of individuals from each of the captive-bred families
- Monitor the effects of the release using molecular methods (e.g. microsatellite DNA markers)

The risks of introducing disease into the wild population were also considered at the stock enhancement workshop and in further discussions with Dr Brian Jones of Agriculture WA. The protocols for assessing diseases in prawns have been developed as a part of the Fisheries WA program on Disease and Hatchery testing and a component of the “Tropical Prawn Diseases” project (FRDC 98/212). Any juvenile prawns produced for stock enhancement would be tested for disease using these protocols.

Conclusions

The bioeconomic model has shown that the stock enhancement of tiger prawns in Exmouth Gulf can be profitable. However, further information is needed on the production of juvenile prawns and the survival of juveniles during the release (i.e. harvest, transport, release), to make better



predictions about the likely success of an enhancement. The technology for the production, harvest, transport and release of juvenile prawns needs to be developed. Further information is also needed on the nursery habitats of the juvenile prawns to develop release strategies that give the maximum chance of a successful enhancement. These information needs are the basis for a three year FRDC project “Developing techniques for enhancing prawn fisheries, with a focus on brown tiger prawns (*Penaeus esculentus*) in Exmouth Gulf” (FRDC 1999/222), which is the second stage in the overall plan for the stock enhancement of tiger prawns in Exmouth Gulf. If the results of Stage 2 are favourable, it would be followed by trial stock enhancements (Stage 3, 1 to 2 million juveniles) and a commercial scale enhancement (Stage 4, 7 to 10 million juveniles) that would attempt to increase the commercial catch by at least 100 t.

Loneragan N, Kenyon R, Die D, Pendrey R, Taylor B

The impact of changes in fishing patterns on red-legged banana prawns (*Penaeus indicus*) in the Joseph Bonaparte Gulf CSIRO, FRDC (\$55 014)

1996-1997

Summary

- Tagging did not affect either the growth or survival of *Penaeus indicus* under laboratory conditions. The results of this study show that a large-scale field tag/release experiment in Joseph Bonaparte Gulf should be feasible.
- There was no difference in growth or mortality between the tagged and control prawns. Growth of all prawns was higher in the large 5000 l tanks than in the much smaller 50 l tanks. The mortality of both tagged and control prawns was higher in small tanks than large tanks. Female *P. indicus* grow faster than males.
- A prototype release cage was developed and tested under calm conditions in shallow water, the release mechanism activated successfully and the prawns left the cage. However, under extreme conditions in Joseph Bonaparte Gulf, the cage was less successful. The release cage reached depths greater than 60 m, however, upon retrieval, some prawns remained in the release cage to within 3 m of the surface.
- Tagging in Joseph Bonaparte Gulf would be very dependent on weather. It would be impossible to tag and release prawns under the conditions that the cage was tested. An improved release cage design is currently being developed.
- Logbook data were used to examine effort patterns in the Joseph Bonaparte Gulf during different seasonal closures. In the early years of the fishery (1981-84), effort was concentrated at the end of the year (September to December), in 1985-86 effort was more in the middle of the year (June to September), whereas in recent years (1988-1995) effort peaks in May and June.



- Length frequency data and data on the maturity of red-legged banana prawns collected by Rik Buckworth of NT Fisheries were analysed to estimate parameters of growth and reproduction, and estimate the seasonal pattern of recruitment to the fishery. The estimates of growth rate were unreliable and as a consequence best estimates were obtained from the literature for *P. merguensis*. The seasonal pattern of recruitment from the length frequency data suggests that most prawns recruit to the fishery between February and April. However, no length frequency data are available for the months between December and February.
- The yield, value of the catch and egg production were estimated for different seasonal patterns of effort using a per-recruit model (S_{IMSYS}). The results from this model show that both yield and value can vary by as much as 15% depending on the pattern of effort. However, the results of the model were sensitive to the estimates of growth and mortality, which highlights the need to obtain better estimates of these parameters.

Robins J et al.

Effects-of-trawling subprogram: commercialisation of bycatch reduction strategies and devices in northern Australian prawn trawl fisheries

FRDC QDPI, AMC, Qld and NPF Industry (\$473 688)

1996-1999

Edited draft of non-technical summary

The current project aimed to inform, develop and encourage the use of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) by working collaboratively with the prawn trawling industry of northern Australia. The project also examined the possibility of modifying the headline height of trawl nets to reduce bycatch. We used several strategies to disseminate the relevant information about TEDs and BRDs. Methods included:

- Informal, hands-on workshops at ports throughout northern Australia, these demonstrated the various gears available
- Attending industry meetings and informally visiting the wharves to discuss gear with fishers
- Distribution of dedicated bycatch newsletters and videos summarising TED and BRD issues
- Loans to skippers of TEDs and BRDs custom-built to suit individual needs
- At-sea assistance with testing of TEDs and BRDs
- An incentive award, the Prawn Trawling Innovation and Adoption Award to recognise the contribution of individuals within the northern Australian trawl industry to the development and adoption of TEDs and BRDs.



Tangible outcomes included face-to-face contact by project staff with about 30% of the prawn trawl operators in the Queensland East Coast Trawl Fishery and about 60% in the Northern Prawn Fishery. Over 400 fishers, net makers, conservationists and other industry personnel, attended TED and BRD workshops. Sixty-eight TEDs and 13 BRDs were lent to commercial fishers. Supervised field tests of TEDs and BRDs occurred on 37 vessels. Research staff spent over 418 days in the field, and recorded performance data on over 828 tows during which a TED or BRD was fitted to a trawl net.

TEDs were very effective at excluding sea turtles and other large animals. In total, 14 turtles were caught in standard nets, while two turtles were caught in TED-equipped nets (i.e. the net was winched in with the turtle positioned at the base of the grid). Generalisations about the effects of TEDs on prawn catches were difficult to make, because of variable results. A reduction in prawn catch of between 4% and 10% occurred during many of the supervised at-sea testing of TEDs. However, prawn catch rates were maintained or increased (average 7%) during several supervised TED tests. On some vessels, prawn loss in the TED equipped net was excessive (e.g. 50%), but could be attributed to a particular cause such as shallow grid angle. On other vessels, excessive prawn loss occurred (e.g. 29%), no obvious cause could be found. BRDs had a varied effect on unwanted fish bycatch. Exclusion rates depended on the design of the BRD, the composition and quantity of bycatch, and whether trawling was undertaken during the day or night. In most cases, bycatch reduction averaged about 20% during night trawling and about 40% during day trawling. The data collected suggested that BRDs had little impact on prawn catches.

The recipients of the Prawn Trawling Innovation and Adoption were John Olsen in 1997 and Garry Anderson in 1998. Both recipients actively promoted TED and BRD use amongst their fellow fishers and were ambassadors for progress industry had made in reducing unwanted bycatch.

Results from the multi-level beam trawl work suggested that about 96% of most commercial prawn species and 90% of the bycatch entered the trawl within 600 mm of the seabed. This suggests that the majority of the unwanted bycatch live close to the seabed like prawns. As such, the potential for reducing bycatch simply by reducing the headline height of the trawl seems to be poor. Many fish species demonstrated strong upward escape responses to the approach of the trawl and the strategic placement of BRDs in the top panel of the trawl might be required to exclude these species successfully.

Less tangible outcomes of the project were the exchange of knowledge and information between project staff and individuals within the trawl industry. Information distributed by the project provided an important starting point for the manufacture and use of TEDs and BRDs by fishers and net makers of northern Australia. First-hand experience using TEDs and BRDs led many individuals to begin developing their own designs. Providing fishers with information that would allow them to understand the underlying principles of fish exclusion assisted this.



Less than 2% of the Queensland East Coast Trawl fleet used BRDs, and only two vessels (out of 920) regularly used TEDs when the project began in 1996. A similar situation prevailed in the Northern Prawn Fishery. No NPF vessels were known to regularly use TEDs in the NPF in 1996, but seven vessels were known to have tested a TED previously. TEDs and BRDs were not commercially available and the skipper or owner of the vessel made most of the devices in use. A wide variety of TED and BRD designs are now commercially available from at least 20 commercial suppliers in ports throughout northern Australia. From the beginning of 2000, TEDs and BRDs were compulsory in all NPF trawlers. While the project targeted otter trawl operations, the concepts and designs for fish exclusion from trawl nets have been utilised by several operators in beam trawl fleet of the Queensland East Coast. This is an example of the change in industry attitudes towards bycatch reduction amongst many trawl fishers.

This project clearly demonstrated that a focused extension program can effectively raise the awareness of the fishing industry to sensitive issues, such as sea turtle bycatch, and encourage the use of “environmentally friendly” fishing practices. It also clearly demonstrated that the provision of research and extension information does not necessarily cause or induce all industry operators to change their practices.

Stobutzki I, Blaber S, Brewer D, Fry G, Heales D, Jones P, Miller M, Milton D, Salini J, Van der Velde T, Wang Y, Wassenberg T, Dredge M, Courtney T, Chilcott J, Eayrs S
 Effects-of-trawling subprogram: ecological sustainability of bycatch and biodiversity in prawn trawl fisheries CSIRO, QDPI, AMC, FRDC (\$1 477 390)
 1996-1999

Edited draft of summary of final report

This project covered bycatch issues in the NPF, the Torres Strait Prawn Fishery and the Queensland Banana Prawn Fishery. This edited summary deals only with the NPF.

1) Description of the bycatch of the NPF

Areas of high trawl effort were sampled by scientific surveys and by an observer on commercial boats to describe the bycatch. The bycatch was very diverse; 390 species of fish, 56 species of elasmobranchs (sharks, rays and sawfishes) and 234 invertebrate taxa were recorded. Fish species made up about 73% of the bycatch weight. Because most fish die after capture, most bycatch does not survive trawling. Three families, Bathysauridae (lizardfish or grinnners), Leiognathidae (pony fishes) and Nemipteridae (monocled bream), made up 41% of the weight. Most of the fish species were rare. The bycatch differed across the areas of the fisheries and with time of year. NPF fishing areas can be divided into two on the basis of the bycatch composition. These two regions were dominated by different species of prawn and both should be included in any bycatch monitoring program.

2) To assess the impact of trawling on the sustainability of vertebrate bycatch species

Stock assessments for bycatch species are not feasible because bycatch is very diverse and little is known about the biology of most species. Hence, we developed an approach to examine the likely impact of trawling on vertebrate bycatch species and applied this to the NPF. Two overriding characteristics determine the sustainability of bycatch species: the susceptibility of a species to capture and mortality in a prawn trawl (susceptibility) and the capacity of a species to recover once depleted (recovery). A number of biological criteria were assessed for each characteristic. Species were ranked on each characteristic and the ranking reflects their ability to resist fishing pressure and therefore their priority for management, monitoring and research. The fishes, elasmobranchs (sharks, rays and sawfishes) and sea snakes were dealt with separately due to taxonomic and biological differences.

Since the 1980's, 411 fish species have been recorded in NPF bycatch and on average the fishery removes about 6% of their total biomass annually. Thirteen species, from four families ranked as high priority for management, monitoring and research; these are the least likely to be sustainable. They are highly susceptible to trawls because they are benthic or demersal, their main habitat is soft sediments and their diet may include prawns. Their recovery capacity is low. In applying this process we have highlighted important gaps in current knowledge of bycatch species but the ranking must be used with caution. Future research should be aimed at developing a greater understanding of the biology of species and their distribution in the region of the fishery.

The biology of elasmobranchs makes them more susceptible to overfishing than bony fishes because they are long lived, slow growing, reach maturity at a later age and have few young.

Fifty-six species of elasmobranchs have been recorded in the bycatch of the NPF and the average estimated removal by the fishery is 14% of the total biomass. Most are dead when landed on deck (56%) and survival is lower for smaller individuals. Twenty-seven species are the least sustainable, including stingrays (*Dasyatidae*), sawfishes (*Pristidae*), angel sharks (*Squatinae*), zebra sharks (*Stegastomatidae*), shovelnose rays (*Rhinobatidae*) and nurse sharks (*Ginglymostomatidae*).

They are all bottom dwellers, which increases their susceptibility to capture. Research focusing on these high priority species is vital to ensure their long term sustainability. We need to know more about the basic biology, distribution, movement patterns and stock structure of these species.

The introduction of compulsory Turtle Excluder Devices (TEDs) and BRDs in 2000 will result in the exclusion only of large elasmobranchs. Most elasmobranchs caught by trawlers are small and would fit through the bars of the TED and be caught.

The biology of sea snakes also makes them more susceptible to overfishing than bony fishes.

Thirteen species of seasnake are caught in the NPF. About 49% of seasnakes caught in trawls die. Most snakes caught are mature. Our estimates of sea snake catch and biomass of each species indicate that fishing mortality could be 5-6% per year, which appears sustainable for all but 2 species, *Hydrophis pacificus* (Large headed sea snake) and *Disteira kingii* (spectacled sea snake).



In the Gulf of Carpentaria, these two species should receive high priority for further study on the effects of trawling. TEDs and BRDs appear effective at reducing sea snake catch.

3) To assess the effects of prawn trawling on the biodiversity of vertebrate bycatch communities

The vertebrate bycatch community was compared between areas open to trawling and areas that have been protected for 15 years in the western Gulf of Carpentaria. If trawling had a large impact on biodiversity we would expect to see fewer species, lower catch rates and smaller individuals in the open areas. This was not the case; there was no consistent difference in the number of species between open and closed areas or in catch rates between open and closed areas. In general, the mean size of species was greater in the open areas. Although the results were equivocal with respect to the impact of trawling on biodiversity, this does not imply that trawling has no impact. Any differences between open and closed areas may be reduced by the low commercial effort in the open area, aggregated trawling, possible illegal trawling in the closure, and the mobility of species. This combined with high natural variation may obscure any impacts of trawling.

4) To develop cost-effective, accurate and feasible methods of describing and monitoring bycatch.

We carried out studies of sampling and monitoring methods to assist management. Most species are rare, and a sample of 10% of the catch of a single trawl contains about half of the species in the catch and has an 80% sampling error for the rare species. This sample size is the minimum recommended for monitoring. The results suggest that it is not feasible to monitor at a level that will detect a 50% change in catch rate for all taxa, including rare species. However, it may be possible to monitor more common species. The high level of variation in bycatch is contributed to by factors such as moon phase and should be taken into account when developing monitoring programs.

We compared three methods for monitoring NPF bycatch: crew-member observers; trained observer collections; and scientific surveys. The fishery-dependent strategies are the least costly and the best for monitoring rare species. However, crew-member observers cannot collect data on all bycatch without affecting fishing operations. In addition there is a real problem of identification of species, this is difficult given the large number of species in the bycatch. Scientific surveys are most costly, but provide reliable, accurate and immediately available data. They are also the only method of collecting data on bycatch in unfished areas. The design of a monitoring program will depend on the specific objectives. However, any monitoring program should aim to collect information on a suite of bycatch species and be able to detect changes in populations that may be at unsustainable levels.

Other features of a monitoring program are also defined in the report. A monitoring program will be critical to assess whether the bycatch is sustainable or not.



Conclusions

Managing the sustainability of the bycatch is a significant challenge because of the high diversity of the bycatch of these tropical prawn fisheries and the fact that most species are rare. There are clearly some species that are more susceptible to trawling and are unlikely to recover if they are depleted; these species are the least likely to be sustainable. Future research and management should concentrate on these species. The development of a monitoring program for bycatch is not straightforward; the available methods differ in aspects such as data accuracy, reliability and cost. This project provides guidelines that can be used in the development of a monitoring program.

Vance D, Kenyon R, Taylor B

Growth, mortality, movements and nursery habitats of red-legged banana prawns (*Penaeus indicus*) in the Joseph Bonaparte Gulf CSIRO, FRDC (\$850 541)

1996- 2000

Summary of ongoing work

1) Estimates of natural and fishing mortality and growth rates for the red-legged banana prawn in the Joseph Bonaparte Gulf.

About 1016 tonnes of red-legged banana prawns were caught in Joseph Bonaparte Gulf 1997, while about 261 tonnes were caught in 1998. The population estimates from our tag-release-recapture experiments reflect the fishery catch. We estimate the population was 65 million prawns in 1997 and 20 million in 1998. During 1997, about one tagged prawn was taken per tonne of catch, while during 1998, two to three tagged prawns were taken per tonne of catch. Using the data from 1997, we estimated the natural mortality of red-legged banana prawns to be about 5% per week ($M = 0.11$), similar to the common banana prawn, *P. merguensis*, in the Gulf of Carpentaria.

Analysis of our model showed that some aspects of the tag-release experiment including the size of the prawn (in 1997 only), sex of the prawn (not a strong effect), time of release and date of release affected prawn survival. The tag type, tagger, reward paid and location of release had no effect on prawn survival.

An analysis of growth parameters has been undertaken. Fits to the tagging data show that there were significant differences in growth between sexes, but not between years. Our model showed that *P. indicus* grew at a greater rate at 50 days of age (males - 1.42 mm wk⁻¹; females - 1.53 mm wk⁻¹) than later at 100 days (males - 0.82 mm wk⁻¹; females - 1.09 mm wk⁻¹) and 150 days of age (males - 0.48 mm wk⁻¹; females - 0.77 mm wk⁻¹).

2) The distribution of juvenile red-legged banana prawns in coastal Joseph Bonaparte Gulf and the most important habitats used.



Juvenile red-legged banana prawns (*P. indicus*) are found predominantly in the eastern JBG (>90% of all banana prawns in the Fitzmaurice, Victoria and Keep Rivers) and Cambridge Gulf (>73% of all banana prawns). They are found in high abundances (>1000 m⁻²) in some small creeks and gutters at low tide. The western JBG (Berkeley and King George Rivers and many small creeks) have similar high abundances of banana prawns, but they are predominantly *P. merguensis* (>90%). This shows that the distribution of the two species is quite separate and distinct.

Juvenile *P. indicus* are found associated with mangrove-lined mud banks in estuaries and rivers, similar habitats to those identified for *P. merguensis* in the Gulf of Carpentaria. Repeated trawls among different riverine habitats in close proximity showed that *P. indicus* are most abundant in small side-creeks and gutters, compared to large creeks and rivers. They are found in only very low numbers around mid-river mud banks and channels.

3) Mapping of the juvenile nursery habitats on the ArcVIEW and ArcINFO GIS database

AUSLIG electronic map data were incorporated into a JBG GIS. Three potential juvenile red-legged banana prawn habitat types – mangroves, salt-flats and land-subject-to-inundation - were identified from these data and mapped. The area of each habitat and the linear extent of the habitat/water interface of likely habitats of *P. indicus* have been calculated. The abundances of juvenile *P. indicus* have been incorporated into the GIS, and relationships between prawn abundance and habitat have been investigated. No distinct relationship was found between prawn abundance and any aspect of habitat.

4) Other aspects of GIS that have been investigated

We used three methods (topographical data, aerial photography and Landsat Thematic Mapper satellite imagery) to estimate the area and linear extent of juvenile banana prawn habitats (mangroves and salt-flats) in the Berkeley River and the Lyne River in Joseph Bonaparte Gulf. The Australian Land Information Group (AUSLIG) topographical dataset is digitised from topographical maps at a scale of 1:250,000, and includes such features as mangroves, salt-flats, land subject to inundation, and rivers. Black and white aerial photographs were obtained from the WA Department of Conservation and Land Management (CALM). These were classified to provide a coverage of mangroves and salt-flats. Landsat TM satellite imagery was purchased, and used to classify the mangroves and salt-flats.

For each method, the area and linear extent of each type of habitat was calculated and compared among methods to gauge the best method to use to estimate habitat. The results show that, at this scale, the aerial photographs provide the most accurate estimates of both area and linear extent of habitats, as verified by ground-truthing, while the topographical data was the least accurate. Landsat TM imagery gives good estimates of the area of habitats, but underestimates the linear extents. The differences in the estimates are attributed to differences in the resolution of each of



the methods. The mangroves of the Joseph Bonaparte Gulf region typically form narrow fringes that can be detected only at a high resolution. While aerial photographs give the most accurate results for individual river systems, Landsat TM imagery and topographical data can be useful tools in broader-scale studies.

Other findings

Freshwater discharge from the Ord River Irrigation Scheme affects the distribution of *P. indicus* and *P. merguensis* in the Ord River. The all-year-round discharge from the irrigation scheme lowers the salinity in the Ord River. At low tide, the salinity is 0-5 ppt just upstream from its confluence with Cambridge Gulf. The abundance of juvenile banana prawns at sites in the Ord River was low to non-existent, and much lower than in comparable rivers and sites flowing into Cambridge Gulf that we sampled at the same time. We stopped travelling up the Ord to sample as there were no prawns at several sites and the water was fresh.

Changes to river flows (i.e. inputs of fresh water) elsewhere in the Joseph Bonaparte Gulf system may have an affect of reducing the estuarine habitat available to juvenile prawns and other estuarine fauna.

Wang Y, Die D, Ellis N

Estimation of population parameters for Australian prawn fisheries

CSIRO, FRDC (\$69 524)

1995-1998

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Non-technical summary:

One of the main objectives of fisheries management is to ensure the sustainability of fished stocks. To reach this objective scientists have to adequately assess the status of fished populations with quantitative models of the fishery systems. Most of these models require estimates of population parameters such as growth rates, mortality rates and catchability (the proportion of the population caught by a single vessel each day). Most of these parameters are unique for each stock; unfortunately they are not easily estimated because marine organisms are inherently difficult to observe and study. Estimation is generally done through statistical analysis of catch data, either from the fishery or from research surveys.

Tropical prawns are fast growing organisms that reach maturity in a few months and tend to be predated upon or caught before they reach a year of age. Prawns are also animals for which age can not be easily determined because they have no hard structures that are retained through their life.

As a result age cannot be estimated and can be inferred only indirectly from their size.

The combination of a short life-span and the inability to age individuals is a major difficulty in developing estimation methods for populations of tropical prawns. This is especially the case for those parameters that are time dependent (such as mortality and growth rates).



This document reports on two years of work devoted to developing new statistical methods for the estimation of population parameters in tropical prawn fisheries. The work was divided into five components:

- 1 Review of current methods of estimating growth and mortality rates
- 2 Development of new methods for the estimation of growth and mortality rates
- 3 Development of a method for the estimation of size-specific mortality rates
- 4 Study of the dynamics of prawn aggregations
- 5 Estimating the effects of effort and aggregation dynamics on catchability

In the review of current methods we investigated three models that use length frequency data to estimate growth and mortality. The first two of these methods ignore differences in size for individuals of the same age and assume all prawns recruit at the same time. As a consequence these methods provide substantially biased estimates of population parameters. The last method considered did accommodate different sizes at age and gave unbiased results. This last method, however, provided very uncertain estimates, with large confidence limits suggesting that estimates were accurate but not precise. This review concluded that it was imperative to develop new methods, more appropriate for the life history and fishery characteristics of tropical prawn fisheries.

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A new method was then developed for estimation of mortality rates and growth parameters from length frequency data by incorporating individual growth variability within the model. The method is flexible enough to accommodate for different recruitment patterns, length-specific gear selectivity and varying fishing effort over time. This method is statistically robust and was tested with data for grooved tiger prawns from Northern Australia.

All the methods mentioned above make the fundamental assumption that the natural mortality rate does not change with the age or size of the prawn. We used data for common banana prawns to show this assumption is certainly not correct for juvenile prawns. We found considerable changes in the natural mortality of juvenile prawns, from 40% mortality per week for the smallest juveniles (4mm carapace length) to only 5% mortality per week for the larger ones (12mm carapace length). This suggests that there is a need to revise the evidence for size-independence of natural mortality rates for larger prawns.

Schooling is a well-known behavioural trait in fish but it is less common in prawns. In Australia, there is at least one group of prawns that form dense schools, the banana prawns. Other prawn species aggregate but in much smaller densities. We have used logbook data to describe the



dynamics of prawn schools. We found that the apparent biomass of schooling banana prawns decreases due to fishing more rapidly than that of non-schooling banana prawns. This implies that the density and catchability of banana prawn stocks decreases as the season progresses. This possibly invalidates earlier assessments of banana prawn stocks that assumed catchability was constant throughout the season.

At larger spatial scales we examined the relation between the effects of non-random distribution of fishing effort and abundance. Models used to analyse the catch and effort data from the Northern Prawn Fishery suggest that there has been an increase in catchability due to the reduction in abundance of tiger prawns and the tendency of tiger prawns to aggregate.

In conclusion this project has made substantial progress in developing appropriate methods for parameter estimation for tropical prawn stocks. Some of these methods have been successfully used to show that previous estimates of growth parameters, mortality rates, and catchability may have been subject to substantial bias or relied on untenable assumptions. This research has therefore contributed to correct such estimates at the same time as providing a set of new statistical tools that can be used for other Australian prawn stocks.

Dichmont C

Risk analysis and sustainability indicators for prawn stocks in the Northern Prawn Fishery

CSIRO, FRDC (\$226 524)

1998-2000

31

Objectives

- 1 To assess the probability that current NPF prawn stocks are being fished at sustainable levels (as defined by performance indicators of stock status developed by NORMAC) by carrying out a risk analysis.
- 2 To predict the performance of future NPF management alternatives by comparing predicted stock parameters against NORMAC's performance indicators of stock status.

Non-technical Summary

This project has been highly successful at determining factors that affect the outputs and outcomes of the Northern Prawn Fishery stock assessment model and the uncertainty underlying the model system. Key results of the research includes:

- Improved methods of splitting the catch and effort into the 6 major prawn species and augmenting the logbook records (to accommodate missing information) to the known historical landings. Three methods, two of which are new, were investigated and the uncertainty intervals in these methods determined.
- The use of Vessel Monitoring System (VMS) data for impacts of trawling and stock assessment studies. Based on recommendations of previous studies, vessels entering three

6-minute by 6-minute grids were polled every 20 minutes. The resultant tracks were calculated and displayed in ARC/INFO. The method developed is new to the NPF.

- Detailed analysis of the effects of changes to the input data (output from Chapters 2 and 3), the model assumptions and variability. The subsequent output variability of the estimates and management reference points is highlighted. Two new stock assessments were developed, the one is based on the Wang and Die (1996) assessment and the other is a derivation of the Deriso-Schnute assessment. A multi-stock model formulation of these were also developed. The Deriso-Schnute assessment is forward projected to a 20-year horizon. This is the first time the standard (albeit modified) assessment of the tiger prawns has been projected. The projections were evaluated in terms of risk (the frequency of the 20th year spawning stock size falling below the spawning stock size at the Maximum Sustainable Yield) and reward (average future catch). Various constant effort (including the effort at the Maximum Sustainable Yield, E_{MSY}) levels were considered. The effects of recruitment variability are also considered.

Conclusions

- The report shows that there is little uncertainty in the augmentation method used in the past and surprisingly little difference between the three methods tested. However, there is indication that the species split between *Penaeus semisulcatus* and *P. esculentus* in the last few years has changed substantially, but due to lack of data during that period the results could not be conclusively shown. Sampling of tiger prawn species proportions in the catch is essential as this risk remains undetected and the results on the model output and management advice could be substantial.
- The VMS work was novel and highly interesting as little past work on this data type gave us any prior indication of its analysis and usefulness. The high polling frequency data is excellent for fishing intensity studies. Linking the data to the catch and effort logbook information however, was extremely difficult. The spatial scale of the VMS data is much smaller than that of a single logbook record from a night's fishing for one vessel. Combining the high intensity data with surrounding low intensity data was much more useful. Unfortunately, access problems to the data severely compromised the research, and resolving these difficulties should be a high priority to enable this promising research to be completed expeditiously.
- The highest risk that would affect the management advice is the level of fishing power. Three levels of constant proportional increases in annual fishing power were compared with two other schemes where annually varying rates were used. These latter effort increase schemes were produced by the Northern Prawn Fishery Assessment Group in conjunction with D J Sterling. In almost all the risks tested, the tiger resources were deemed to be overexploited.



- The results also show the productivity of the resource to be surprisingly low. The present reference points relating to the Maximum Sustainable Yield could only be estimated with high uncertainty. It is recommended therefore that appropriate reference points for a highly variable short lived and input controlled resource is determined as a matter of urgency.
- The future projections show distinct risk-reward relationships for the two tiger prawn species. The mid-season closure has been extremely beneficial for *P. semisulcatus*. This, combined with the fact that little effort is directed towards the species in the first half of the year, allows many prawns to spawn before capture. This is not the case for *P. esculentus* as a large portion of the effort in recent years occurred in the first half of the year. At low levels of effort, the largest component of risk is recruitment variability. This high level of recruitment variability is combined with serial correlation. Constant effort levels can at certain times be sequentially higher than is appropriate for the below average recruitment. The low productivity of the resource does not easily allow full recovery during the above average recruitment years.
- It is recommended that a more variable management option be investigated in a management Strategy Evaluation framework. The feedback loops will reveal whether increased management variability and/or the availability of certain data would be beneficial (given its cost) by lowering the risk for little or no decrease in reward.

Outputs

- A new robust assessment of the dynamics and status of the tiger prawn species based on a detailed review of the input parameter/data and model assumptions.
- The distribution and spatial structure of the stock(s) has been established and has been factored into a successful new research proposal.
- There are reliable estimates of all removals and their uncertainty from the fished stock. These estimates have been incorporated into the stock assessment. There are detailed risk-reward functions that consider the effect of model uncertainty in the reference points.
- There are tools to directly investigate management options.

Vance D

Definition of effective spawning stocks of commercial tiger prawns in the Northern Prawn Fishery and king prawns in the Eastern King Prawn Fishery: behaviour of post-larval prawns

CSIRO, FRDC (\$449 168)

1997-2000



Objectives

- 1 Measure the critical vertical migration behaviour of post larval tiger and king prawns that determines their inshore advection patterns.
- 2 Incorporate this behaviour into hydrodynamic models to accurately estimate the effective spawning stocks of tiger and king prawns.

Non-technical Summary

To effectively manage most fisheries, including penaeid prawn fisheries in northern and eastern Australia, it is important to know the relationship between the size of the spawning population and the number of young adults that recruit to a fishery in the next generation. In the tiger prawn fishery in the Gulf of Carpentaria, it has been assumed for management purposes that the total adult population at a particular time is the effective spawning stock, i.e. all spawners contribute to the next generation's stock. This is not necessarily correct and is particularly unlikely for many species of penaeid prawns, whose larvae and postlarvae have to migrate from offshore spawning areas to coastal and estuarine nursery areas. The area that contains spawners that actually contribute offspring to subsequent adult populations has been termed the "effective spawning area".

Hydrodynamic modelling of water currents in the south-eastern Gulf of Carpentaria has shown that most of the banana prawn larvae (*Penaeus merguensis*) produced during the autumn fishing season (when adult banana prawns are most abundant) are lost to the population due to unfavourable currents. The hydrodynamic model has also been used to estimate the size of the effective spawning areas for tiger prawns in the Gulf. Recent research has emphasised the importance of the vertical migration behaviour of the postlarvae themselves in enabling the postlarvae to be advected towards the coastal nursery areas. In particular, if postlarvae cue their behaviour to the tidal cycle, i.e. they move up into the water column on flood tides and settle on the seabed during ebb tides, they will be advected more quickly to the coastal areas than if they do not respond to the tides. We know that postlarvae of some penaeid prawn species are cued to flood tides when they are in relatively shallow estuarine waters (< 5 m) but not in deeper offshore waters (> 20 m).

The depth at which postlarvae start to cue to flood tides (the "transition depth") has a major impact on the estimates of effective spawning area calculated by the hydrodynamic model. For example, if the depth at which postlarvae become tidally cued is reduced from 20 to 7 m then effective spawning areas in different regions of the Gulf of Carpentaria decline by between 20 and 60%.

The main aim of our project was to investigate the vertical migration behaviour of postlarval penaeid prawns that enables them to recruit from offshore spawning areas to the coastal nursery areas. We used two strategies to achieve this aim: field sampling in estuaries in southern and northern Queensland and laboratory experiments.



Field sampling

The aim of the field sampling was to determine at what stage of the tidal and day-night cycles postlarvae in inshore waters are most active in the water column. We sampled for four 24-hour periods in the Nerang River, Southport and six 24-hour periods in the Embley River, Weipa in 1998 and 1999. During each sampling period, we trawled once every hour with a 1-mm mesh plankton net at the surface and with a beam trawl with three separate vertical compartments on and just above the seabed. At Southport we made good catches of the eastern king prawn, *Penaeus plebejus* and at Weipa we obtained data for two species of tiger prawns, *Penaeus esculentus* and *P. semisulcatus*, and for the banana prawn, *P. merguensis*.

The overall pattern of catches was very similar for all the species. The largest catches of postlarvae at the estuary surface were usually made on flood tides at night. Much smaller catches were made at the surface on flood tides during the day and very few postlarvae were caught there on ebb tides. Patterns of catches of postlarvae in the beam trawls near the seabed were less clear and less consistent between species. The response to both tide and day-night was strongest for the eastern king prawn. The results showed clearly that both tide and day-night cycles affect the vertical migration behaviour of penaeid postlarvae when they are in relatively shallow inshore waters.

Laboratory experiments

The aim of the laboratory experiments was to determine at what water depth postlarvae of the tiger prawns, *Penaeus esculentus* and *P. semisulcatus*, begin to recognise and respond to simulated tidal cycles. We developed computer-controlled apparatus that allowed us to use pressure changes to simulate a sinusoidal tidal cycle with a period of 12 hours and a range of 2 metres. This tidal cycle was superimposed on simulated water depths of 4, 8, 12 and 16 m - again mediated by pressure changes. A day-night cycle of 12-hour days and 12-hour nights was maintained during the tidal experiments. We designed and built a small flow-through activity chamber that allowed us to run experiments for up to 4 days so that the response of postlarvae to a sequence of several tidal cycles could be tested. The activity of the postlarvae was recorded onto videotape using an infrared-sensitive video camera.

We were able to carry out and analyse a total of 64 experiments on postlarvae of the brown tiger prawn, *P. esculentus*, and 17 experiments on postlarvae of the grooved tiger prawn, *P. semisulcatus*. For all species and sizes of postlarvae and all water depths tested, the day-night cycle had a substantial effect on postlarval activity; postlarvae were always more active at night.

We were not able to collect enough data on the smallest sizes of postlarvae to analyse statistically, but medium-sized brown tiger postlarvae clearly responded to the tidal cycle when the water depth was set to 4 m. However, they did not respond to the tide when the water depth was 8 m or greater. Large postlarvae responded to the tidal cycle at 4 and 8 m but not at 12 or 16 m. Large grooved tiger postlarvae also responded to the tidal cycle at 4 and 8 m but not at 12 or 16 m.



We carried out further short-term experiments on a larger size range of brown tiger postlarvae to more clearly understand their response to water depth. The activity of the postlarvae was monitored while water depth was increased linearly from 3 to 7 m over 1 hour, held at constant water depth for 2 hours, and then decreased linearly from 7 to 3 m over 1 hour. We found that small postlarvae did not change their activity levels in response to the depth changes at all. However, medium and large postlarvae were significantly more active when the depth was decreasing and just after the pressure had decreased.

Conclusions

Our results suggest that medium-sized tiger prawn postlarvae would start to detect tidal cycles at water depths somewhere between 4 and 8 m and small postlarvae probably do not recognise the tides at all. The effective spawning areas for tiger prawns in the Gulf of Carpentaria are therefore probably quite small compared to the total area fished commercially and are mostly inshore of the commercial fishing grounds. Based on the hydrodynamic model of larval and postlarval advection, it was estimated that only about 2% of the commercial tiger prawn catch in October (when spawning levels in the fishery were highest) was taken in the effective spawning area if the transition depth was 7 m. Field sampling for adult tiger prawns is needed to confirm that adequate numbers of spawning tiger prawns occur in these relatively shallow inshore waters at the appropriate time of year to constitute an effective spawning stock.

Haddon M

Spatial and seasonal stock dynamics of Northern Tiger Prawns using fine-scale commercial catch-effort data TAFI, FRDC (\$80 915)
1999-2000

Objectives

- 1 Determine whether the spatial and temporal scales of fleet behaviour bias the interpretation of the tiger prawn stock dynamics when analysed by a non-equilibrium stock-production model
- 2 Prepare NPFAG Working Papers that will include full descriptions of the model structure, data analyses and potential management implications
- 3 Communicate to the Northern Prawn Fleet and industry the results of the analyses in a format such that the implications become clear to everyone and that permits comments and criticisms by industry members

Non-Technical Summary:

The northern tiger prawn fishery, primarily based in the Gulf of Carpentaria, is a vital part of the Northern Prawn Fishery. This is an input managed fishery that, in August 2000, moved to using a



limited number of gear units to manage effort applied to the stock. This change in management has been brought about at least partly because of perceived problems with the health of the stock and the need to reduce the applied effort. The present assessment, based on the Wang & Die (1996) model, indicates that the fishery is presently close to the management target of E_{MSY} .

Nevertheless, despite recent cuts in effort, aimed at allowing the rebuilding of the spawning stock, the catch rates experienced in the fishery have not recovered as expected. The model developed in this present work suggests that the stock is in fact severely depleted down to only approximately 13% of the average unfished biomass and that there is an urgent need to control effort or reduce fishing mortality. The geographical range over which the fishery is prosecuted has also reduced in recent years. Neither of these indications bode well for the fishery.

In this present work, the Northern Prawn Fishery database was checked for potential internal inconsistencies and records fully on land and duplicate records were identified so that analyses, based upon the information in the database, could avoid using these erroneous records. A list of the erroneous records will be given to the data managers responsible for the maintenance of the database so that they can be permanently deleted.

The catch rate data from the commercial logbook data has been standardised relative to year, month, week, 30-minute geographical area, and the amount of banana prawn caught. All of these factors had highly significant effects upon catch rates. The data standardisation had more effect upon the apparent trend in catch rates in the 1970s and 1980s than it did in the 1990s. This may be a reflection of the fleet becoming more similar in its equipment and methods of fishing. Whatever the case may be, with the approach to standardisation used and documented in this work we have enhanced the ability of producing repeatable summary information regarding the fishery performance. The changes in the seasonal nature of the fishery were emphasised and had to be included in the assessment. Likewise, the spatial distribution of the fishery was demonstrated to be of vital importance to understanding the dynamics of the fishery. It was shown that the areas of greatest fishing pressure had reduced in the Groote and Melville statistical areas, especially the latter, which was dominant early in the fishery, to more effort being applied in the Mornington and Vanderlins statistical areas. This change reflects the long-term average catch rates being slightly higher in these areas.

The new model developed during this work has provided an alternative stock assessment for the northern tiger prawn fishery and enabled a clearer view of the levels of uncertainty associated with the assessment. To move from a deterministic, apparently precise assessment, to one that admits to uncertainty in the parameter estimates may appear to be a step backwards. However, it is better (meaning safer for the prawn stocks) to be aware of the limitations of an assessment than to mistakenly believe that an assessment is precise when it is not. The new model also lends itself more easily to permitting risk assessments of different management options than the older assessment. Such risk assessments are important to obtain the full benefits possible from the new gear unit



management regime. Having more than one assessment model is beneficial in permitting the results from each to be compared leading to a greater understanding of the implications of the available information for the status of the prawn stocks.

The new model is based upon a yearly time scale and has been developed as far as perhaps it should. If more years of data accrue in which no recovery is seen the model will begin to be unstable so there is a need to develop a model with an explicit time-step of two or four weeks. This future model could be either a surplus-production model or a delay-difference model.

The objectives of the study were achieved by the investigations into the spatial distribution and seasonality of the fishery using the raw commercial logbook data and the model developed during this project. Three papers summarizing the work in progress were presented to the Northern Prawn Fishery Assessment Group, and less formal presentations were made (both written and verbal) to a large Fishing Industry gathering during the Northern Prawn Fishery Strategic Planning Meeting in June.

The new model has been adopted as part of the tiger prawn assessment process and the Principle Investigator is now a member of the Northern Prawn Fishery Assessment Group and the NORMAC Research and Environment Committee.



Objectives of Research in Progress in the NPF

Note: The name of the Principal Investigator is given first and is used for arranging the summaries in alphabetical order. The years refer to the starting and finishing dates. Agencies contributing to the funding of the project are listed. Dollar amounts are only those attributed to NPF and are not necessarily the total cost of the project. In some cases it was not possible to extract the cost of the project.

ABARE staff

Flexible seasonal restrictions in the northern prawn fishery

ABARE, FRRF (Cost not available)

1999-2000

Objectives

- 1 Develop a set of variable closure rules that could be used to expand management options in the Northern Prawn Fishery.
- 2 Improve understanding of the spatial dimension of fishing activity and catch in the Northern Prawn Fishery.

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Chesson J et al

Application of ESD Evaluation Framework to Commonwealth Fisheries

BRS (\$19 000)

1998-2000

Project description

The Bureau of Rural Sciences has previously developed a framework for assessing performance with respect to ecologically sustainable development (ESD) (Chesson and Clayton 1998). In this project, the framework is being applied to the major Commonwealth fisheries including the Northern Prawn Fishery. The framework consists of a structure and a set of procedures to apply to the structure. The project report, which is near completion, concentrates on the first two procedures, identifying relevant components and specifying objectives. Each individual fishery chapter provides an initial suggestion of relevant components and documents the objectives for that fishery as stated in management plans, policy statements and other materials. This information will be a useful resource for fisheries embarking on processes such as assessment under the *Wildlife Protection Act (Regulation of Export and Imports) Act 1982*, the *Environmental Protection and Biodiversity Conservation Act 1999* and the Standing Committee on Fisheries and Aquaculture ESD Initiative.

Dichmont C

A new approach to fishing power analysis and its application in the Northern Prawn Fishery

CSIRO, AFMA Research Funds, FRR, AMC, Curtin University (\$354 873)

1999-2001

Objectives

- 1 Improve present knowledge on engine power performance, effective fishing time and catch efficiency
- 2 Validate the Prawn Trawl Performance Prediction Model against engineering performance information
- 3 Produce a comprehensive effort effectiveness model that combines engineering concepts and statistical methodology incorporating results from 1 to 2 above and analysing data on catch, effort, vessel configuration and technology on board from 1974 to present
- 4 Improve estimates of changes in fishing power in the Northern Prawn fishery by making them more reliable and justifiable
- 5 Reassess the status of stocks in the light of changes in estimates of fishing power
- 6 In consultation with management bodies, investigate possible management strategies to control fishing effort and its effects on sustainability and the industry

40

Eayrs S

An assessment of TED performance in the banana prawn fishery, Gulf of Carpentaria

AMC, MIRF (\$30 825)

2001

Objectives (Note this project was deferred to 2001 because of poor banana prawns catches in 2000)

- 1 To measure turtle catch rates in a standard trawl whilst target fishing for banana prawns
- 2 To assess the condition of turtles caught during short tows and provide a first order estimate of likely survival rates
- 3 To measure the effect of TEDs on banana prawn catches. (Effect of BRDs on prawn catches will also be assessed depending on the number of operators willing to participate in this study and the number of observers available)



Hill B, Gooday P, Taylor P, Haywood M

Developing surrogates for species assemblages, assessing the impacts of trawling and modeling the performance of spatial closures in the Northern Prawn Fishery

CSIRO, FRDC, ABARE, EA, BRS (\$550 591)

2000 - 2002

Objectives

- 1 Assess the potential of physical, research and fishery data to classify benthic assemblages within the NPF
- 2 Develop maps of benthic species assemblages, fine-scale patterns of trawling intensity and the untrawlable grounds for key areas in the NPF
- 3 Assess the sampling strategies required to extend the coverage of data on benthic species assemblages and untrawlable grounds in the NPF
- 4 Apply the existing CSIRO/GBRMPA East Coast Trawl Fishery management scenario evaluation model to evaluate the impacts of trawling on benthic species assemblages under a number of likely scenarios for several regions of the NPF
- 5 Develop a planning tool that will assist in identifying different reserve configurations to achieve specified biodiversity and other environmental targets, while maximising the value of the commercial fishery

41

Loneragan N

Developing techniques for enhancing prawn fisheries, leading to experimental releases of juvenile brown tiger prawns (*Penaeus esculentus*) in Exmouth Gulf

CSIRO Division of Marine Research and Division of Tropical Agriculture, MG Kailis Group of Companies, Fisheries WA, FRDC (\$128 850)

1999-2002 (Stage II)

Objectives

- 1 Minimise the costs of producing large numbers of juvenile prawns through research on techniques to intensively grow larvae to juvenile prawns (1 g), and developing methods of harvest, transport and release
- 2 Maximise the possibility of the success of releasing juvenile prawns in the environment by surveying the critical nursery habitats of brown tiger prawns in Exmouth Gulf (including the juvenile prawns and their predators)



- 3 Ensure that the cost and success of prawn enhancement can be rigorously evaluated by developing release protocols and monitoring strategies, and by refining the bioeconomic model developed in Stage 1
- 4 Minimise the risks of large changes in the genetic composition of the tiger prawn stocks and introducing disease to the wild population

Robins C

Monitoring the catch of turtles in the Northern Prawn Fishery

FRDC, BRS, CSIRO (\$162 274)

1998 - 2000

Objectives

- 1 To collect detailed baseline information on the species composition, catch and mortality rates of sea turtles captured incidentally by the Northern Prawn Fishery in 1998 and 1999.
- 2 To use these results to:
 - (a) Measure the impact of the 1988/92 restructure, and predict the impact of the proposed effort adjustment package (1998/99) and the introduction of bycatch reduction devices (BRDs) into the NPF on the incidental catch of sea turtles
 - (b) Improve the current AFMA logbook monitoring of turtle bycatch in the NPF.

42

Slattery S

Electronic cooking end point determination and the effectiveness of alternate cooking methods for crustacea

QDPI, FRDC ((\$32 146)

1998-2000

Objectives

- 1 To develop a device which will determine endpoint of cooking for crustacea by:
 - (a) determining crustacean protease deactivation temperature curves
 - (b) developing a durable sensor for measuring the thermal centre of the crustacea
- 2 To confirm that protease deactivation as the endpoint for cooking, as determined by the above device, is effective by:
 - (a) on site trials of several species, sizes and cooking rates
 - (b) effects on possible melanosis development, sensory and textural quality, and yield



- 3 To Evaluate alternate cooking/processing conditions for prawns
- 4 To produce 10 prototype devices for demonstration in commercial trials.
- 5 To extend results to industry through workshops, publications and media.

Sterling D (DJ Sterling Trawl Gear Services)

Effort Creep Review

NPF Industry (\$1 440)

2000

Objective

- 1 Provide a qualitative analysis of all potential effort creep scenarios in the NPF

Stobutzki I, McCrum S, Nock C, Nichols J, Nelson C, Carter D, Lowe L, LaMacchia T, Boot I, Sant G, Jackson P, Eayrs S, Geen, G

Assessment and improvement of BRDs and TEDs in the NPF: a co-operative approach by fishers, scientists, fisheries technologists, economists and conservationists

CSIRO, FRDC (\$1 165 233)

2000-2002

Objectives

- 1 To optimise the performance of approved BRDs and TEDs on NPF vessels
- 2 To identify the factors influencing the performance of BRDs and TEDs
- 3 To measure any change in catch rates of total unwanted bycatch and in particular, selected charismatic or vulnerable bycatch species, due to the use of BRDs and TEDs
- 4 To measure any changes in catches of commercially important prawns and retained byproduct species due to the use of BRDs and TEDs
- 5 To assess the economic costs and benefits to industry of the use of BRDs and TEDs
- 6 To establish a protocol for the ongoing development and testing of new BRDs and TEDs



Vance D

Management of common banana prawn stocks of the Gulf of Carpentaria: separating the effects of fishing from those of the environment

CSIRO, FRDC (\$108 019)

1999-2000

Objectives

- 1 Review the influence of the environment and fishing on the long-term catch of banana prawns.
- 2 Provide a new assessment of the status of common banana prawn resources in the NPF.
- 3 Obtain better predictive models to forecast the annual catch of banana prawns.

Willoughby C

Australian Prawn Industry Code of Practice

FRDC, APPA, NPF Industry (\$219 581)

1999-2001

Objectives

The project will provide the basis for a Quality Management System for the Australian sea-caught prawn industry by:

- 1 reviewing, validating and updating the Code of Practice to ensure it establishes an agreed set of standards across the industry, applicable and achievable in all fisheries, covering boats and shore-based processing operations and all markets
- 2 establishing a training regime by creating a core of trainers to implement a 'train the trainer' program so that trawler crews and shore-based processing staff thoroughly understand the requirements and their responsibilities in catching and processing the product, with a support network to provide assistance and advice; assistance with development of Food Safety Plans and adoption of ISO 9002 standards will also be provided where requested.
- 3 developing a third party auditable certification quality management system based on the industry quality standards in the Code of Practice; a single audit will incorporate quality and regulatory standards – AQIS, State and ANZFA requirements and be agreed by all regulatory authorities
- 4 ensuring that the quality management system is capable of modular expansion to incorporate standards for Occupational Health and Safety, environmental protection and sustainable trawling.



Dichmont C

A new approach to assessment in the NPF: spatial models in a management strategy environment that includes uncertainty

FRDC, CSIRO, TAFI (\$580,289)

2001-2003

Objectives

- 1 Develop a new multi-stock multi-species operating model for the Northern Prawn Fishery.
- 2 Using the model from (1), to develop alternative Management Targets and Reference Points appropriate for stock level, multi-species management that explicitly includes variability
- 3 Evaluate the performance of management strategies that relate to these new management targets and indicators.
- 4 Communicate the advantages and disadvantages of the alternative options (model, target, and strategy) to Industry and the NORMAC.

Poiner I

Monitoring of banana prawns in the Southeast Gulf of Carpentaria roadstead.

Pasminco, NORMAC, CSIRO, TAFI (\$128,346)

2001-2003.

Objectives

- 1 Monitor the level of heavy metals (Cd, Cu, Pb and Zn) in banana prawns (hepatopancreas and tail meat) sampled in the Gulf of Carpentaria within the Pasminco Roadstead and control areas to the northeast and southwest.

Ovenden J

Development of a genetic method to estimate effective spawner numbers in tiger prawn fisheries

FRDC, QDPI (\$667,892); Flow of Benefits: 40% to the NPF.

2001-2003

Summary

The tiger prawn trawl fisheries located in the Gulf of Carpentaria and on the Queensland coast export over \$150m worth of product annually and provide significant regional employment. Our aim is to develop improved methods of estimating spawning stock size in these fisheries as errors can lead to overfishing and industry collapse. A new genetic method will be developed, using tiger prawns as a model, which will indirectly count the number of breeding adults, lead to more accurate predictions of recruitment and improve the spatial resolution of spawning stocks. The method may prove applicable to other heavily exploited fisheries.

Objectives

- 1 To critically evaluate a variety of mathematical methods of calculating N_e by conducting comprehensive computer simulations and by analysis of empirical data collected from the Moreton Bay population of tiger prawns.
- 2 To lay the groundwork for the application of the technology in the NPF.
- 3 To produce software for the calculation of N_e , and to make it widely available.

Hall M

The development of manufactured attractants as a means to harvest prawns specifically

FRDC, AIMS (\$359,208); Flow of Benefits: 35% to the NPF.

2000-2002

Objectives

- 1 To quantify the attraction and specificity of pheromones from crustacea in experimental environments.
- 2 To develop methods suitable for isolating and concentrating pheromones from crustacea, especially penaeid prawns.
- 3 To identify mechanism for manufacturing a bait incorporating these novel attractants.



Appendix 1.

NORMAC REC – 2001/02

Activity Timetable

Timing	Activity
February 2001	NORMAC REC to: <ul style="list-style-type: none"> • review research priorities for 2001/02; and, • review 5-year research plan.
February 2001	NORMAC endorses 2001/02 research priorities
April 2001	Advise research providers of priority research areas and call for research pre-proposals, against these priorities, for 2001/02.
July 2001	Draft 2002/03 Research Plan circulated to REC members for comment.
7 August 2001	Research proposals for 2001/02 reviewed and ranked by REC and recommendations forwarded to NORMAC 51 for endorsement
August 2001	Research providers informed of NORMAC's recommendations
September 2001	Full proposals for 2001/02 to be submitted to the NORMAC REC for final review against NORMAC's recommendations.
1 October 2001	MAC-endorsed and ranked full applications to be submitted to the ARC for AFMA funding
7-8 November 2001	ARC to meet with scientific members of MACs to discuss applications and reviews applications
November 2001	NORMAC REC meets in Canberra to: <ul style="list-style-type: none"> • review the 5-year research plan and update accordingly • review operations of the REC • review the revised Bycatch Action Plan including the development of the crew based observer program in 2002 and the BRD workshop in February 2002 • review the strategic assessment of the fishery • review the results of the NORMAC/Pasminco monitoring of the SE



GoC roadstead

- discuss the stock assessment research priorities from the NPF FAG
- discuss the development of the Environmental Management System
- review research issues arising from the NPF 5-year Strategic Plan
- review research funding

6-7 December 2001

AFMA Board considers and approves research projects for AFMA Research Funding

mid-December 2001

The ARC advises outcomes to applicants for AFMA Research Funding

February 2002

NPF BRD workshop in February 2002



Appendix 2 NORMAC REC Members as at June 2001

NORMAC REC members	PHONE NO:	FAX NO:	EMAIL:
Dr Ian Poiner (Chair) Scientific Member NORMAC	07-3826 7223 0419 702652	07-3826 7281	ian.poiner@marine.csiro.au
Mr David Carter Industry Member NORMAC	08-9202 2444	08-9443 7750	dcarter@newfish.com.au
Dr Malcolm Haddon University of Tasmania	03-6227 7279	03-6227 8035	malcolm.haddon@utas.edu.au
Mr Eddie Hegerl Environment/Conservation Member NORMAC	07-3206 8687 0401 148576	07-3206-8687	ehegerl@ozemail.com.au
Dr Neil Loneragan CSIRO	07-3826 7225	07-3826 7222	neil.loneragan@marine.csiro.au
Ms Theresa Lowe Industry	07-4035 1951	07-4035 1947	gnmchandlery@internetnorth.com.au
Ms Katrina Maguire Environmental Manager AFMA	02-6272 4258	02-6272 5167	katrina.maguire@afma.gov.au
Mr Mike O'Brien Industry	07-3399 1944 0411 595910	07-3399 1960	mobrien@raptis.com.au
Mr Phil Robson Industry	07-3249 7817 (c/- Barbara Maslin)	08-9443 7750	prrobson@acenet.net.au
Ms Cathy Dichmont Chair – NORMAC Fishery Assessment Group also attends NORMAC REC meetings	07-3826 7219	07-3826 7222	cathy.dichmont@marine.csiro.au

