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# Harvest Strategy

## FOR THE NORTHERN PRAWN FISHERY UNDER INPUT CONTROLS 2012

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**Title**

Harvest Strategy for the Northern Prawn Fishery under Input Controls

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# CONTENTS

# 1. OVERVIEW

The Northern Prawn Fishery (NPF) harvest strategy was developed in line with the Commonwealth Fisheries Harvest Strategy Policy (2007), which in turn sits under the Ministerial Direction (2005). The objective of the Harvest Strategy Policy is the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity through the implementation of harvest strategies that maintain key commercial stocks at ecologically sustainable levels and within this context, maximise the economic returns to the Australian community.

A harvest strategy sets out the management actions necessary to achieve defined biological and economic objectives and must contain a process for monitoring and conducting assessments to the conditions of the fishery, and rules that control the intensity of fishing activity (known as control rules).

To meet the objective of the Harvest Strategy Policy, harvest strategies aim to pursue an exploitation rate that keeps fish stocks at a level equal to Maximum Economic Yield (MEY) and ensure stocks remain above a limit biomass level ($B_{LIM}$) at least 90% of the time.

The Harvest Strategy Policy provides for the use of proxy settings for reference points to cater for unique fishery circumstances. This balance between prescription and flexibility will encourage the development of innovation and cost effective strategies to meet key policy objectives. Proxies must ensure stock conservation and economic performance as envisaged by the Harvest Strategy Policy. Such proxies, including those that exceed these minimum standards must be clearly justified.

With a harvest strategy in place, fishery managers and industry are able to operate with greater confidence, management decisions are more transparent, and there will be fewer unanticipated outcomes necessitating hasty management responses.

Further detail on how to use harvest strategies is provided in the Guidelines to the Harvest Strategy Policy (Commonwealth Fisheries Harvest Strategy Policy Guidelines 2007).

## 2. BACKGROUND

In the past, the management objective for the NPF tiger prawn fishery was Maximum Sustainable Yields (MSY). For management purposes this was broken down into the levels of spawning stock which should produce the maximum sustainable yield ($S_{MSY}$), and the level of fishing effort which should produce maximum sustainable yield ($E_{MSY}$). Until 2001, the target reference point was $S_{MSY}$. $E_{MSY}$ was essentially treated as a limit below which serious remedial action would be implemented.

In 2000, the tiger prawn stock assessment indicated that biomass of brown tiger prawns was conclusively below $S_{MSY}$. The biomass of grooved tiger prawns was also assessed as below $S_{MSY}$, but not as depleted as the brown tiger prawn population. In response to this assessment, the Northern Prawn Fishery Management Advisory Committee (NORMAC) agreed to rebuild brown and grooved tiger prawn stocks to $S_{MSY}$ within five years (by the end of 2006). NORMAC agreed to adopt a new, more conservative target reference point being: 'there is a 70+% chance that the spawner population at the end of 2006 will be above or at spawner level targets ($S_{MSY}$).' A stock rebuilding strategy to pursue this reference point for tiger prawns was implemented at that time. The stock rebuilding strategy was successful and the 2006 stock assessment indicated that recovery has occurred and that both species of tiger prawns are no longer overfished.

NORMAC subsequently agreed in 2003 to adopt MEY as the target reference point for the tiger prawn fishery. $S_{MSY}$ was set as the point at which overfishing occurs and treated as the overfishing limit reference point, once recovery has been achieved. MEY has subsequently been adopted as the aspirational target reference point in Harvest Strategy Policy.

The harvest strategy described in this document addresses the biological elements of achieving the MEY objective. Strategies to improve cost efficiencies (i.e. economic efficiency) which will be required to pursue MEY will be addressed as the results of further analysis become available.

As a result of the current investigation of output controls for the fishery, NORMAC is adopting a two stage approach to the development of harvest strategies for the NPF. The first stage is to develop harvest strategies based on the current input control system, using a single control measure (gear units) to be applied to the management of the main target species, combined with other management measures (i.e. spatial and temporal closures).

The second stage will be to develop harvest strategies for implementation under an output control system[1] however that cannot be done until such time as the research required to set robust and effective Total Allowable Catches (TACs) has been undertaken, and an appropriate output control system has been designed for the fishery.

This Harvest Strategy document is the first stage in the development of harvest strategies for the NPF, for management under input controls. A key output of this Harvest Strategy is to provide an operating framework which will deliver stock sustainability and maximise the economic return of the fishery.

**The harvest strategies in this paper have been tested using the NPF Management Strategy Evaluation (MSE) model.**

This Harvest Strategy comprises the following key elements:

[1] Subject to outcomes of discussions on optimal management arrangements for the fishery

- Indicators (data from the fishery)
- Monitoring (agreed protocols to get data)
- Reference points (targets and limits)
- Method of assessment (e.g. stock assessment, Catch per Unit of Effort (CPUE) standardisation)
- Decision rules (agreed rules for setting catch levels)

The target and reference points and the confidence levels adopted in this strategy have been developed to address the short-lived, multi-species nature of the target species in the NPF.

Prawns grow rapidly and most reach commercial size and reproductive maturity at the age of 6 months, although they take 9 to 12 months to reach the larger, more valuable, sizes (Dall *et al.* 1990). Given the short-lived nature of prawns, inter-annual variability of recruitment can be extremely large and unpredictable. This is especially true for white banana prawns (*Penaeus merguiensis*) where there is a link between high rainfall and banana prawn catch, although this connection is moderated by the interaction between rainfall and catchment size (Vance *et al.* 1998). The key element to the assessment of tiger prawns, a species much less influenced by environmental factors and therefore displays less inter-annual variability in recruitment, is that there is a stock-recruitment relationship (with surprisingly low steepness values) (Penn and Caputi 1986, Ye 2000, Wang and Die 1996, Dichmont *et al.* 2003). Given the fact that the catch in a year is dominated by a single year class, it is not surprising that, compared to more long-lived species' assessment, there are reasonably large confidence intervals in the estimates of spawning stock and recruitment size whether using an age-based assessment (Wang and Die 1996), a delay difference assessment (Dichmont *et al.* 2003) or a biomass dynamic model (Haddon 2001). These confidence intervals mean that, when a stock median estimate is at MSY, the 90% confidence interval can range from 80 to 130% of $S_{MSY}$ in any single year. As previously noted this imprecision requires that the harvest strategy for the fishery is effective in the longer term, rather than in any particular year (in the short term).

It is well-known that it is impossible to achieve MSY for all stocks when multiple stocks are fished simultaneously. This is already recognised in the NPF through the analyses being conducted to identify the effort levels corresponding to MEY. Similarly, attempts at developing management strategies that achieve $S_{MSY}$ for tiger and endeavour prawn species have shown that only extremely complex harvest strategies are likely to achieve this target for both species (Dichmont *et. al.* 2006, Dichmont *et. al.* 2008). How multi-species technical impacts are handled depends in part on the objectives for the management system, noting the ability to account quantitatively for biological interactions is not sufficiently well-developed for any fishery worldwide. For this fishery, the aim is to achieve $S_{MEY}$ for the tiger prawn fishery maximising the net present value using a dynamic bio-economic multi-species assessment (Punt *et al.* 2010).

For ease of reading, and to reflect the multi-species nature of the NPF, this strategy is divided into harvest strategies for the tiger prawn fishery, (including the endeavour prawns), harvest strategies for the banana prawn fishery, and harvest strategies for other target species and byproduct species.

# 3. LEGISLATIVE OBJECTIVES OF THE FISHERY

## 3.1. Objectives of the Fishery

The Fishery is managed under the *Northern Prawn Fishery Management Plan 1995* (the Plan). The Objectives of the Plan are:

| | |
|---|---|
| Objective 1 | Ensure the utilisation of the fishery resources within the Northern Prawn Fishery is consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle. |
| Objective 2 | Maximise economic efficiency in the utilisation of the fisheries resources within the Northern Prawn Fishery. |
| Objective 3 | Implement efficient and cost effective management of the Fishery. |
| Objective 4 | Effectively communicate and consult with AFMA, the fishing industry, other marine resource users and the broader community. |
| Objective 5 | Ensure that the incidental catch of non-target commercial and other species in the NPF is reduced to a minimum. |

# 4. FISHERY OVERVIEW

## 4.1. Geographical Context

The NPF occupies an area of 771,000 square kilometres off Australia's northern coast (Figure 1). The Fishery extends from the low water mark to the outer edge of the Australian Fishing Zone (AFZ) along approximately 6,000 kilometres of coastline between Cape York in Queensland and Cape Londonderry in Western Australia.

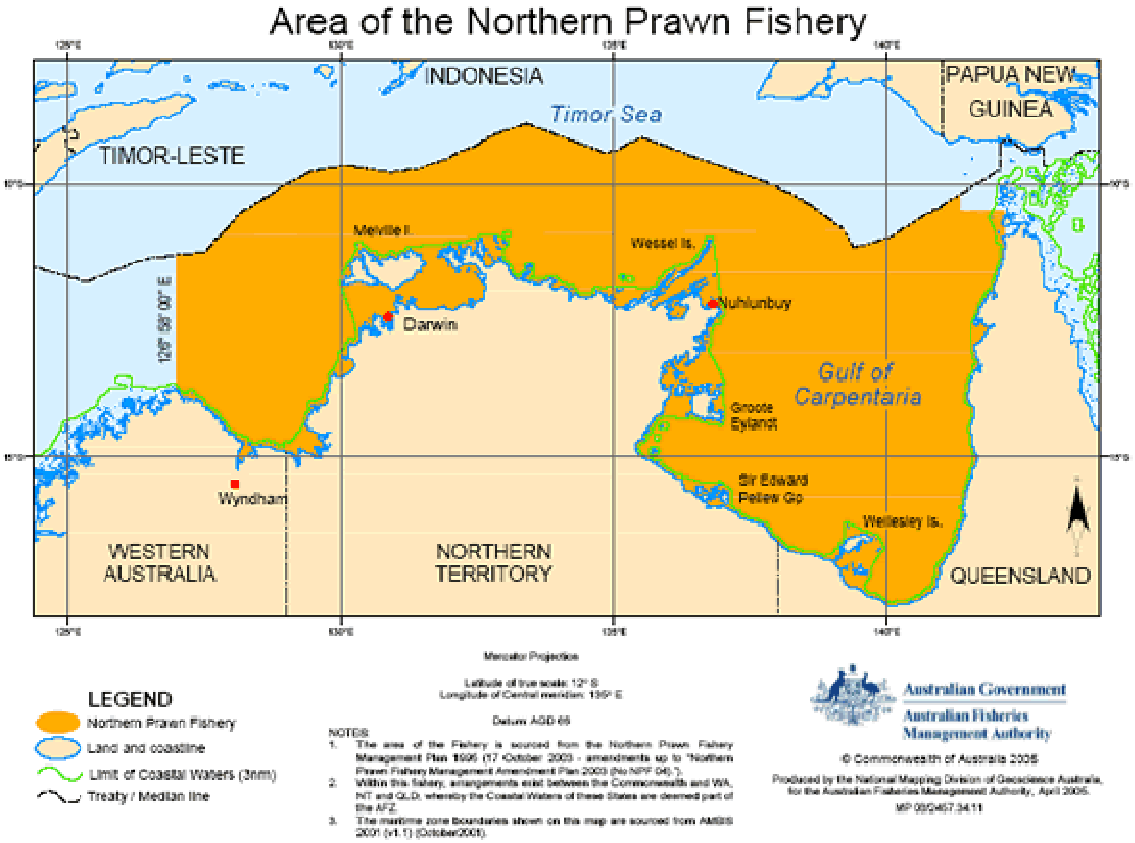


**Figure 1: The spatial extent of the Northern Prawn Fishery**

Under an Offshore Constitutional Settlement (OCS) agreement between the Commonwealth, Western Australia, Northern Territory and Queensland governments, originally signed in 1988, prawn trawling in the area of the NPF to low water mark, is the responsibility of the Commonwealth through the Australian Fisheries Management Authority (AFMA).

Data from the AFMA logbook data base indicates that fishing effort was reported from 273 grids (6 minute x 6 minute) when the fishery opened in 1973. Effort reached a maximum in 1989 when effort was reported in 1,555 grids and it has decreased since then to be reported from 841 grids in 2000 to 742 grids in 2010. There are an estimated 7281 grids in the area of the NPF. Since the early 1980's logbook coverage of the fishery has been virtually 100%.

The principle reasons that much of the area of the NPF managed area is not trawled are:

- the permanent closure of areas (all shallow water seagrass beds);
- the unsuitability of areas to trawling due to large reef outcrops;
- the low density of the target prawn species, (e.g. central Gulf of Carpentaria).

There are also trawlable grounds closed to prawn trawling both seasonally (8.3% of total area) and permanently (2.1% of the total area). These areas include all known seagrass beds. The major trawl grounds are in the Gulf of Carpentaria and the area to the north and south-west of Darwin.

The number of vessels recording catch in the NPF has fallen from 134 in 1995-96 to 52 in 2009-10. This is largely due to the combined results of internal industry restructure between 1996 and 2006; whereby 39 trawl vessels were removed from the Fishery, and the 2006 Commonwealth Structural Adjustment Program in which 43 Class B Statutory Fishing Rights (SFRs) were removed from the Fishery.

There are currently 35,479 gear SFRs issued for the fishery. In 2005 (prior to the structural adjustment scheme), there were 53,844 gear SFRs. This significant change in the management of the fishery has not only seen a reduction in bycatch, but has also provided for less swept area by the trawlers.

The total NPF prawn catch for 2010 was 7,711 t compared with 7,483 t in 2009 (Figure 2). The catches of Banana Prawns in 2010 (5,642 t) was just below that of the previous year (5,881 t). The catches of Tiger Prawns increased by 30% from 1,250 t in 2009 to 1,628 t in 2010. Catches of Endeavour Prawns increased by 24% from 346 t in 2009 to 429 t in 2010. In 2010 catches of King Prawns increased from 7 t in 2009 to 12 t in 2010.

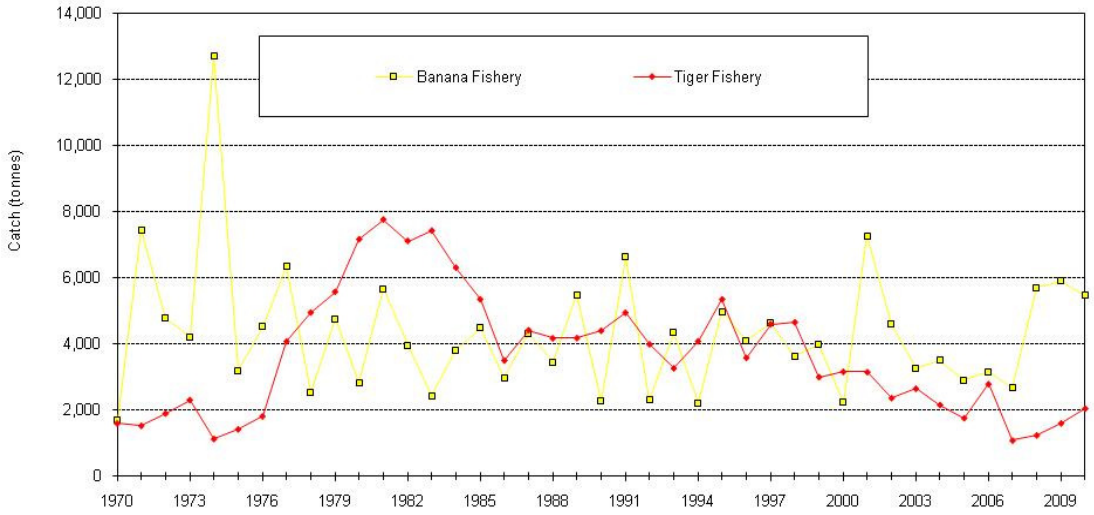


**Figure 2: Catch in the Banana and Tiger Prawn fisheries between 1970 and 2010.**

Nominal effort is the number of days recorded by skippers in their logbooks (Figure 3). A number of different approaches to calculating effort creep have been used by Northern Prawn Fishery Resource Assessment Group (NPRAG). Presently, effort creep for the tiger and red-legged banana prawn fisheries are estimated using statistical models.

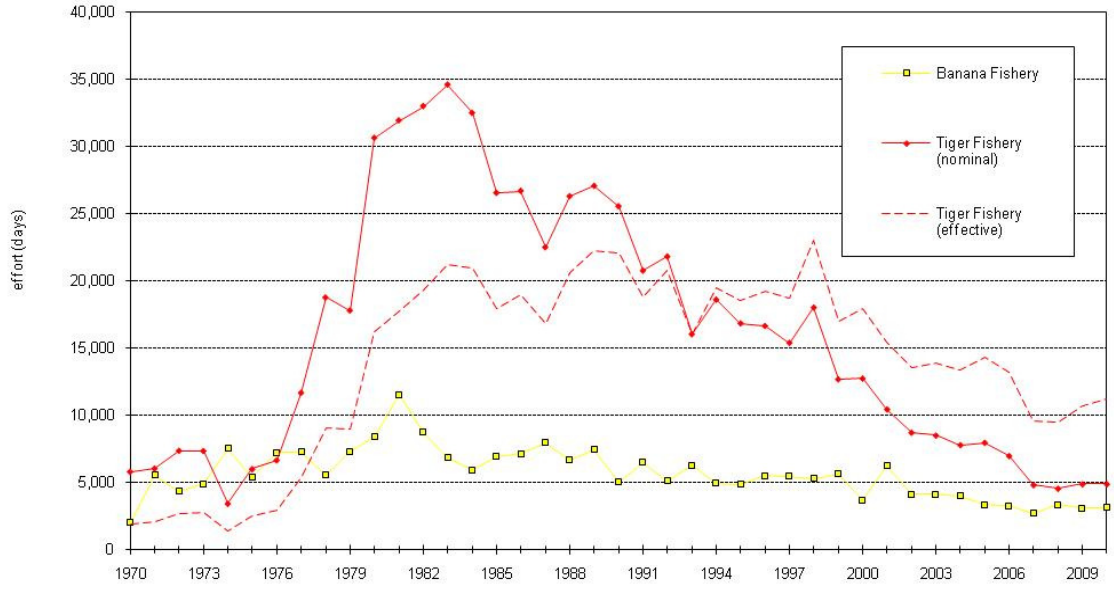


**Figure 3: Effort in the banana and tiger prawn fisheries in the NPF between 1970 and 2010.**

## 4.2. Target Species

Target species are the most highly sought component of the catch taken in a fishery.

The NPF is a multi-species fishery with nine species of prawns being targeted:

- White banana prawn *Fenneropenaeus merguiensis*
- Red-legged banana prawn *Fenneropenaeus indicus*
- Grooved tiger prawn *Penaeus semisulcatus*
- Brown tiger prawn *Penaeus esculentus*
- Blue endeavour prawn *Metapenaeus endeavouri*
- Red endeavour prawn *Metapenaeus ensis*
- Western king prawn *Melicertus latisulcatus*
- Red spot king prawn *Melicertus longistylus*
- Black tiger prawn *Penaeus monodon*

The prawn species fall into four general categories of banana, tiger, endeavour and king prawns however individual species are not distinguished within those groups in the commercial catch. Extensive studies by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Marine Research, including commercial catch sampling and analysis of substrate composition, have shown that the adults of the two commercial species of tiger prawns have different spatial distributions. These are related to type of substrate and water depth. This has allowed the commercial catch category of tiger prawns to be approximately split between the two species according to the six minute square grids. Dichmont *et al.* 2001 updated the species split methodology in 2001and included the potential for species split shifts over time and area. This was further updated in 2006 to incorporate the results of the Venables *et al.* 2006 species distribution project.

Banana prawns are split into the two component species. Red-legged banana prawns are caught almost exclusively in deep water (>45 metres) in the Joseph Bonaparte Gulf (JBG) and white banana prawns elsewhere (Dichmont *et al.* 2001).

White banana prawns, brown tiger prawns and grooved tiger prawns account for almost 80% of the total annual catch from the fishery. The remainder is made up mostly of endeavour prawns and red-legged banana prawns.

Prawn species reach a commercial size at six months, and can live for up to two years. Larger sizes bring the highest price. Growth rates vary considerably between species and sexes, with females generally growing faster and to a larger size than males. Most species are sexually mature at six months, but fecundity increases with age. A twelve-month-old female can produce hundreds of thousands of eggs at a single spawning and may spawn more than once in a season. The eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the two to four week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months on the nursery grounds, the young prawns move offshore onto the fishing grounds.

During 2010 the catch of prawns was 7,111 t, comprised of 5,881 t of banana prawns, 1,628 t of tiger prawns, 429 t of endeavour prawns and 12 t of king prawn species.

The other target species listed in the NPF Management Plan are squid and scampi. However given the low volume and the low value of squid taken by NPF trawlers, squid is treated as a byproduct in this Harvest Strategy. Numerous other byproduct species including bugs, scallops and various fish species are also taken during trawling operations. Approximately 27 tonnes of non-prawn byproduct was also landed in 2010.

## 4.3. Value of the Fishery

The NPF is the most valuable Commonwealth managed fishery and is one of the most valuable fisheries in Australia. The annual gross value of production (GVP) of the fishery has varied between $65 million and $168 million AUD. This can be attributed to the fluctuating annual catch, season lengths, market conditions and foreign exchange rates.

The real GVP of the fishery in 2009-10 was $88 million. The majority of the tiger prawn catch from the fishery is exported, predominantly to Japan however, exports to China and countries within the European Union are increasing. Approximately 80– 90% of white banana prawns are sold on the domestic market.

## 4.4. Management Regime

The NPF is managed through a series of input controls, including limited entry to the fishery, gear restrictions, bycatch restrictions and system of seasonal, spatial and temporal closures.

To fish in the NPF operators must hold Statutory Fishing Rights (SFRs), which control fishing capacity by placing limits on the numbers of trawlers and the amount of gear permitted in the fishery.

There are two types of SFRs:

- a Class B SFR, which permits a boat to fish in the NPF; and
- a gear SFR, which limits the amount of net a fisher can use.

There are currently 35,479 gear SFRs issued for the fishery. The total number of Class B SFRs in the fishery is 52.

Operators must hold both Class B SFRs and the appropriate number of gear SFRs for the length of headrope they wish to use to operate in the fishery. There is a minimum holding of 100 gear SFRs for each Class B SFR.

A gear SFR currently represents 9 cm of operational headrope for operators towing twin gear and 8.1 cm of headrope for operators towing quad gear or tongue nets.

The fishery currently has assessments for brown and grooved tiger prawns. Assessments are also being developed for the banana and endeavour species. The tiger prawn fishery is the most valuable component of the NPF and management of the NPF is primarily based around this part of the fishery. Endeavour and king prawns are generally caught as incidental catch of tiger prawn fishing activities.

Under input controls, it is possible to manage the target species according to the lowest common denominator. The endeavour and king prawn resources are generally protected by the management measures adopted for the tiger prawn resource, as well as through spatial and temporal closures.

The banana prawn fishery is managed by a fixed length season, with some in-season management aimed primarily at allowing a maximum season length in highly productive years, and reducing the season length in years of low production.

## 4.5. Closures

A comprehensive system of spatial and temporal closures is in place in the NPF to address biological and economic objectives of the fishery (see Kenyon *et al.* 2005).

A total of 2.1% of the total managed zone of the fishery is subject to permanent closures, while 8.3% is subject to seasonal closures.

Closures in the fishery include permanent closures of seagrass beds and other sensitive habitats and seasonal closures of juvenile prawn stock habitat, which are designed to coincide with recruitment phases, and also to protect pre-spawning prawns. Closures are also in place to ensure prawns are at a commercial size for harvesting.

Seasonal closures are in place to protect small prawns, as well as to protect spawning individuals. In May 2011, the Northern Prawn Fishery Resource Assessment Group (NPRAG) recommended a fixed small prawn closure from 1 December to 1 March of each year. A daylight trawl closure is in place during the second (tiger prawn) fishing season to reduce the capture of spawning tiger prawns.

## 4.6. Fishery Indicators

### 4.6.1. Data

A comprehensive data collection program has been established for the NPF to ensure reliable information is available on which to base management decisions (Figure 4). Information is maintained on all target prawn species taken in the NPF. The comprehensiveness of the program is a product of the high value of the fishery, the management needs of the fishery and the importance of stock assessment to determine the status of the target species.

The data collection program is based on logbooks that provide for catch and effort data to be recorded daily in logsheets. Season Landing Returns are obtained for landings data which are used to verify the logbook catch.

Vessel gear details are also collected which tracks changes in gear and technology in the fishery. This information assists in stock assessments and research being undertaken on effort creep and fishing power studies.

This data forms the basis of the NPF's fishery dependent research program. Targeted fishery independent research, including annual fishery independent surveys for target species and bycatch, is undertaken in the NPF. Each year, a recruitment survey is undertaken on the key fishing grounds of the Gulf of Carpentaria. A spawner survey is undertaken during the mid-season break in winter on the western grounds of the Gulf before and after major changes in the fishery.

These surveys started in 2002. These surveys are a fundamental component of the tiger prawn stock assessment that is used to set the Total Allowable Effort (TAE) as they provide input to the indices of abundance for both recruits and the spawning stock to which the assessment model is fitted (as well as input data to model on the size frequency of estimated prawns).

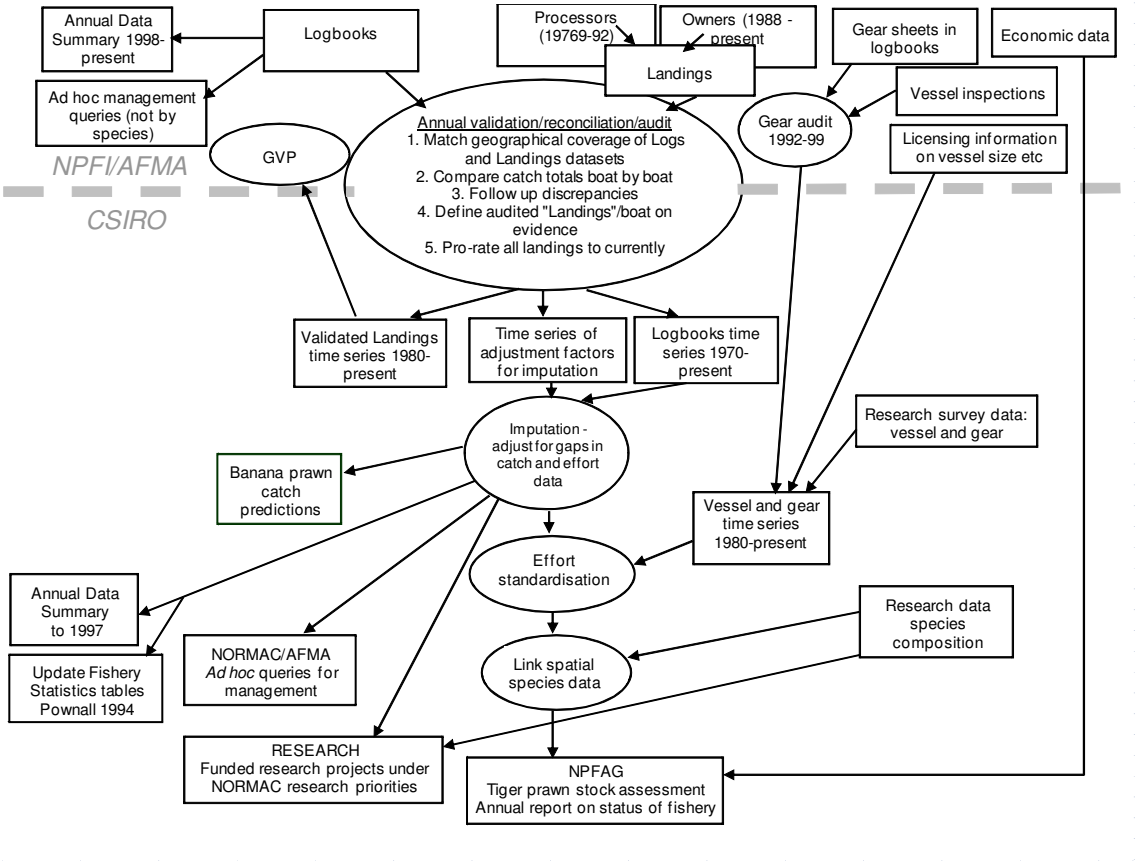


**Figure 4: Sources of data for the Northern Prawn Fishery, and some routine processing pathways.**

Economic data are collected by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) on a regular basis to provide inputs to the NPF's bio-economic model. However, the economic data that is used in the assessment has been collected directly from industry by the NPF Industry Pty Ltd (NPFI) since 2010/11.

### *Data Reliability*

The CSIRO report 'Accuracy of catch and effort data for the Northern Prawn Fishery' concludes that annual landings in the NPF have been estimated reasonably accurately since 1980 by combining information from logbooks to supplement landed weights from prawn processing companies and trawler owners. There have been periods during the early history of the fishery when not all operators provided logbook information. A

detailed augmentation process is used to estimate missing logbook information so that the total logbook catch corresponds to the landings. This information is needed for species specific stock assessments. A detailed investigation of possible errors in this process has been undertaken by Dichmont *et al.* (2001) and found to be small.

The NPF has a long time series of data available for scientific analysis. CSIRO holds a copy of logbook data and annual reconciled landings since 1970. AFMA has had primary responsibility for collecting, collating and verifying the logbook and vessel register data and providing this data to CSIRO. The NPFI assumed responsibility for data management, including reconciliation, collation and provision of data to CSIRO in 2008.

Economic data from the NPF has been collected by the Commonwealth government's economic research agency, ABARES since the 1980's. Bi-annual economic surveys are carried out by ABARES, aimed at capturing financial information from approximately 40% of the fleet. The financial information is provided by NPF operators with small, medium and large trawlers on a voluntary basis. The information collected in the surveys is used by ABARES to calculate the economic performance of the fishery. ABARES survey information is also used by the Department of Agriculture, Fisheries and Forestry to assess the performance of AFMA in managing fisheries. These economic data are not collected at the scale required for the bio-economic assessment and are often not timely enough. For this reason, economic data required for the assessment is collected directly from the industry as a separate process.

## 4.7. Fishery Monitoring

The fishery has a number of monitoring processes in place which will continue under this harvest strategy. These are:

(a) An annual Gulf of Carpentaria wide independent data collection program (at sea survey) which was implemented in the fishery in August 2002. The survey has two modules:

- a January/February survey which provides data for a fishery independent recruitment index for banana, tiger and endeavour prawns; and
- a June/July survey which provides information to examine the spatial distribution in the fishery and attempt to quantify changes in fishing power, one of the key areas of contention with the current model.

(b) Scientific data is collected through these surveys for all target species and a range of bycatch species.

(c) Scientific and crew member observer programs on commercial trawlers to collect data and to monitor bycatch.

(d) A fishery-wide Daily Catch & Effort logbook program for all target and byproduct species and to record interactions with protected species. Under this program, operators are required to record the location of fishing operations (latitude/longitude) for every day they fish and/or search, regardless of whether any catch is taken; the total number of shots for each fishing day; the species/product retained and size grade information.

(e) Seasonal Landings Returns used to reconcile logbook data (target and byproduct species) against commercial landings.

(f) A gear monitoring program to monitor vessel fishing power and Turtle Excluder Devices (TED)/Bycatch Reduction Device (BRD) configurations. Mandatory data collected through the program includes vessel length; beam; depth; engine make

and model; engine power; max. trawl Revolutions per Minute (RPM); Operating RPM; gear box reduction ratio; kort nozzle; propeller diameter and pitch; plotter make and model; sonar; max. speed; trawl speed (banana and tiger prawn fisheries); TED and BRD configurations.

(g) Gear surveys to contribute to fishing power analyses and identification of new gear technologies.

(h) Vessel Monitoring System (VMS) data that covers the whole fleet throughout the season to monitor position of vessels especially with respect to spatial and temporal closures.

(i) Occasional specifically designed VMS polling over a short period to monitor vessel speed.

(j) ABARES surveys to collect economic data (and more recently, economic data collected directly from industry by NPFI).

# 5. THE TIGER PRAWN FISHERY [2]

Tiger prawns are caught predominantly in the second half of the first season and the second season. While tiger prawns remain the target, endeavour and king prawns are predominantly caught incidentally. Bugs are the main byproduct of this fishery. During this season and at specific moon phases, some of the fleet also fish for red-leg banana prawns in the Joseph Bonaparte Gulf.

The operational gear (length of headrope/footrope), which is allowed to be towed in the fishery each year, is adjusted according to the outcomes of the bio-economic model. The outputs from the bio-economic model (which includes the biology of tiger and endeavour prawns, and key economic variables) are used to set the level of standardised effort for the fishery.

## 5.1. Operational Objective

The operational objective of this Harvest Strategy is to attain long term MEY from the tiger prawn fishery.

It is noted that MEY as applied to this fishery, while an equilibrium concept, is not constant, but depends on the expectations of future prices and costs. Further, MEY is not independent of the dynamic path chosen to achieve MEY. For operational purposes, the objective of MEY can be considered equivalent to the objective of maximising the net present value of the flow of profits in the fishery over an indefinite period. For the NPF, MEY is assumed to be achieved over a seven-year period. The dynamic path to MEY is calculated as the effort level and associated catch in each year over a seven year projection period that leads to a long run sustainable yield that maximises profits over time.

## 5.2. Fishery Monitoring

(a) An annual fishery-independent data collection program based on two modules:

- a January/February survey which provides data for fishery-independent recruitment indices for banana, tiger and endeavour prawns;
- a June/July survey which provides information to examine the spatial distribution of the stock and to attempt to quantify changes in fishing power, which is a key area of contention in the current model;

(b) A fishery-wide Daily Catch & Effort logbook program for tiger, endeavour and king prawns, including vessel gear sheets.

(c) Seasonal Landings Returns (data used to ground truth the logbook data).

(d) Reported industry data on tiger prawn catches in the first (banana prawn) season.

(e) Economic data collected by ABARES every second year; and

(f) Economic data collected from industry for use in the bio-economic model.

[2] For the purpose of this HS, both species of tiger prawns and both species of endeavour prawns comprise the 'tiger prawn fishery'

## 5.3. Fishery Reference Points

### 5.3.1. Stock size

In principle, a stock will be declared overfished if it falls below $0.5S_{MSY}$. However, prawn annual recruitment is highly variable compared to longer-lived species. This means that the reference point cannot be applied using a single year's statistic. For the tiger prawn fishery, the limit reference point for each of the two species of tiger prawns and blue endeavour prawns is the moving average of $S_Y/S_{MSY}$ over the most recent 5 years. Thus, if the moving average falls below 0.5, the species is considered overfished.

The appropriateness of the decision rule (described below) in light of the harvest strategy policy has been confirmed using the Management Strategy Evaluation (MSE) (Dichmont *et al.* 2003, 2008).

To assess whether the tiger prawn fishery has achieved the operational objective of attaining MEY, the Tiger Prawn fishery Target Reference Point (TRP) is $S_{MEY}$. It is recognised, however, that the indicator $S_Y/S_{MEY}$ will vary considerably from year to year as a result of large inter-annual variability in recruitment and in the values of economic parameters.

### 5.3.2. Effort

The target reference point for the economic performance measure of effort is $E_Y/E_{MEY} = 1$. A value greater than 1 indicates that effort for the year was in excess of that estimated to be required to produce MEY. Note, however, that because of natural inter-annual variability, $E_Y/E_{MEY}$ will exhibit considerable variability. Also, the pathway to MEY is part of the annually derived dynamic bio-economic model calculation and therefore, unlike $B_{MSY}$-type reference points, outputs a non-linear effort pathway to MEY.

The fishery is considered to be experiencing overfishing if $E_Y$ is in excess of the effort that would be expected to result in a stock that is overfished, i.e. moving average of $S_Y/S_{MSY}$ over 5 years $\leq 0.5$.

## 5.4. Method of Assessment

The NPRAG has responsibility for assessing the dynamics and status of NPF species. NPRAG comprises fishery scientists, industry members, fishery economists, and the AFMA NPF Manager. The Group uses data from both logbooks and research in its stock assessment work.

### 5.4.1. Tiger Prawns

Several assessments for the Tiger Prawn fishery have been developed over time – a delay difference model (Dichmont *et al.* 2001), Bayesian hierarchical biomass dynamic model (Zhou *et al*., 2009) and a newly developed size-based model (Punt *et al*. 2010). The models can be used in any combination for the different species. The resultant stock assessment and estimated stock-recruitment parameters are then combined with economic parameters to form the bio-economic model (Punt *et al*., 2010, Kompas *et al.*, 2010). In 2011, the NPRAG agreed Base Case assessment was a size-based model for both species of tiger prawns and the biomass dynamic model for blue endeavour prawns.

Two species of endeavour prawns (blue and red endeavour) are caught in the NPF, however blue endeavour prawns are generally predominant. There is an NPRAG-accepted stock assessment model for blue endeavour prawns, but not for red endeavour prawns (Zhou *et al*. 2009; Punt *et al.* 2010). Catches of blue endeavour prawns are

considered along with tiger prawns when assessing MEY in the bio-economic model (Punt *et al.* 2010). In the model, endeavour prawns are treated as being an "incidental catch" of the tiger prawn fishery. This means that blue endeavour prawns are treated as revenue, but does not contribute to costs. Red endeavour prawns are not considered in the bio-economic model as no assessment is available for this species. Their catch is highly variable, unpredictable and usually a small part of the overall prawn catches.

There is limited spatial separation between tiger and endeavour prawns (with the exception of the 'spikes' in catches of red endeavour prawns which occur very occasionally) and the correlation between tiger and endeavour prawn catches is quite high. As endeavour prawns are generally taken as an incidental part of the tiger prawn catch, effort controls that apply to tiger prawns, also apply to endeavour prawns (Pascoe *et al*. 2010). As a result, the multi-species bio-economic model combined with a tiger prawn TAE is expected to move endeavour prawns to their TRP of $S_{MEY}$ (Punt *et al.* 2010). However, a decision rule is included to separately address the possibility that blue endeavour prawns may fall below the Limit Reference Point (LRP) using a tiger prawn TAE.

### 5.4.2. Decision Rules for the Tiger Prawn Fishery[3]

The basis of the tiger prawn decision rules is that, because blue endeavour prawns are a bycatch of the tiger prawn fishery, controlling the season length and TAE of tiger prawns will equally maintain the stock size of blue endeavour prawns. This has been tested in MSE's (Dichmont *et al*. 2008 and Dichmont *et al.*, in prep). There is, however, a specific blue endeavour prawn rule when this species falls below the LRP. The flow chart for the LRPs is given in Figure 5.

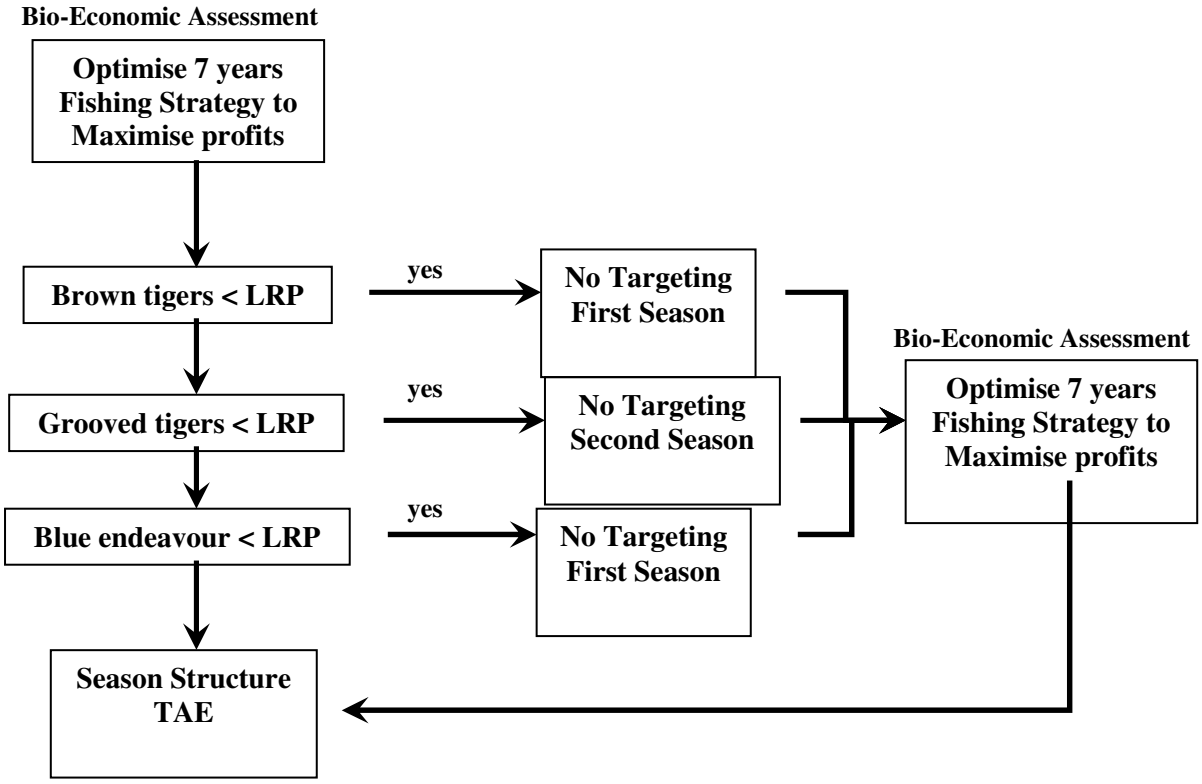


**Figure 5: Flow chart of Limit Reference Point decision rules.**

[3] For the purpose of this HS, both species of tiger prawns and both species of endeavour prawns comprise the 'tiger prawn fishery'. In the context of the MEY target, endeavour prawns are treated as an economic bycatch of the tiger prawn fishery

1. A bio-economic assessment will be undertaken every alternate year, optimising the effort over a seven year moving window to maximise profits.
2. If the LRP is triggered, there will be no target fishing on the target species concerned. Spatial and/or temporal measures will be used to prevent target fishing on species below the limit reference point.
3. Providing the limit reference point is not exceeded, nominal effort for the fleet in any one year can not be less than 1.08 times the nominal effort targeted at brown tiger prawns in 2007.
4. The effort in nominal days for each fleet (brown and grooved) for the first two years from the bio-economic assessment will be applied. This will be calculated as a percentage change from the previous year's actual nominal effort.
5. Effort controls will be applied through the use of spatial and temporal closures, and gear; or any combination of these inputs.
6. If effort changes are to be implemented through gear, the change in effort versus the change in gear will be calculated empirically and calculated based on the percentage gear change from the previous year's gear amount.
7. The figure below (Figure 6) will be used to calculate any required change in total gear.

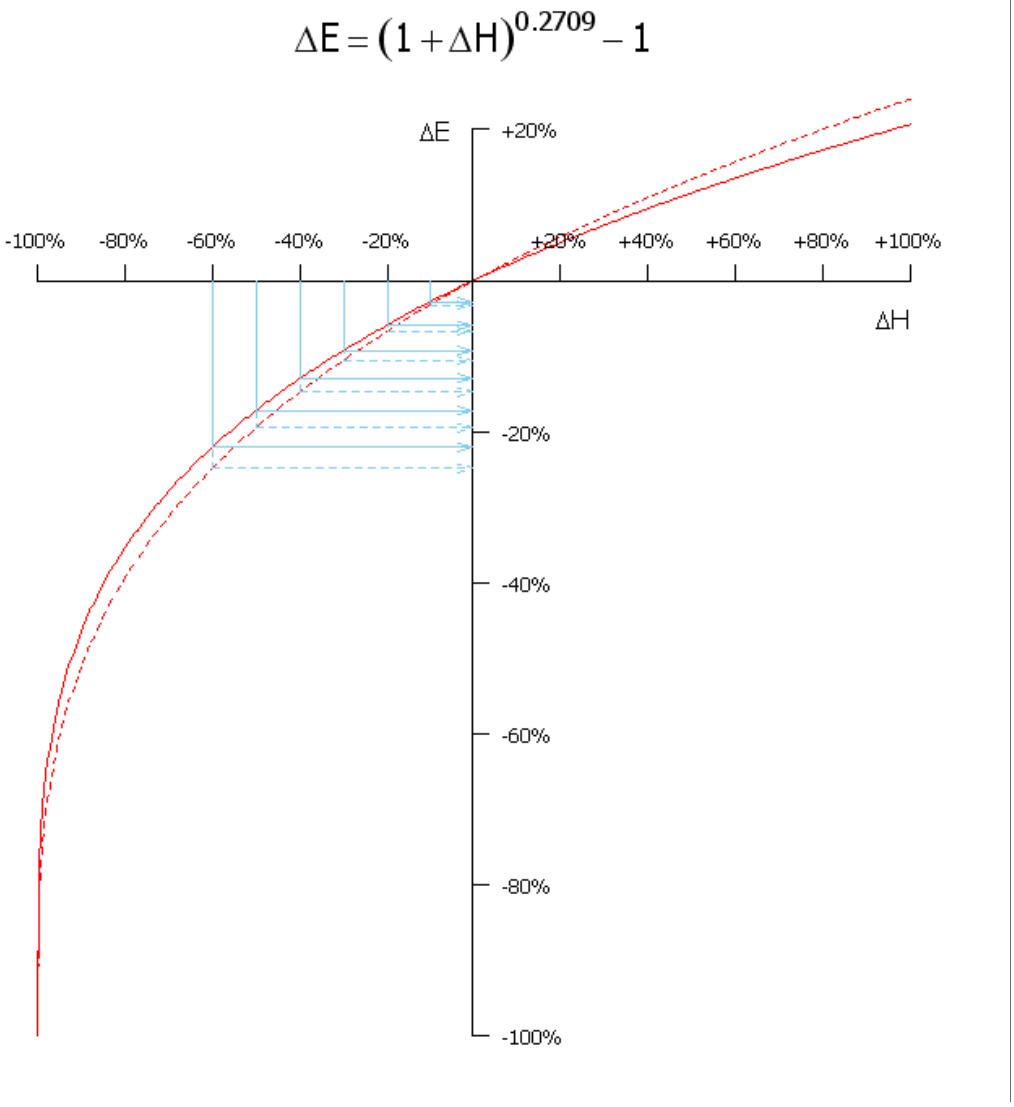


**Figure 6: The relationship between relative increases and reductions in catch for a relative change in headrope length (Venables and Brown, 2007).**

As noted earlier, with the large interannual variability of recruitment that is experienced in a short-lived species such as prawns, it is expected that, on occasions, stock size may fall below 20% of the average level of virgin stock size. The above decision rule will be tested using the MSE to ensure that, if the rule is applied, there is 80% or greater probability that, for all four species, the value of the 5-year moving average of $S_Y/S_{MSY}$ does not fall below 0.5. However, should the monitored value of the moving average of $S_Y/S_{MSY}$ over 5 years actually fall below 0.5, the data will be examined critically by fisheries scientists and the NPRAG will assess whether there is need for a more precautionary management response than that which is called for by the application of the above decision rule.

### 5.4.3. Closures

- Spatial and temporal closures will be used for biological/ecological protection (e.g. seagrass, habitat protection), for prawn size protection (e.g. juveniles, pre-spawning adults) and to maximise prawn growth/ increase economic return.
- Closures will be introduced and/or amended by NORMAC according to the protocols in the NPF Closures Review 2005 report, *"Documenting the history of*

*and providing protocols and criteria for changing existing or establishing new closures in the NPF"*.

- A daylight trawl ban will be used to protect spawning tiger prawns in the second (tiger prawn) season.

# 6. THE BANANA PRAWN FISHERY

## 6.1. Common banana prawns

### 6.1.1. Operational objectives

The operational objective of this Harvest Strategy is to allow sufficient escapement from this fishery to ensure an adequate spawning biomass of Banana Prawns (based on historical data), and to maximise the economic return from the fishery within the above parameter.

### 6.1.2. Indicators

- Banana prawn catch and catch per unit effort data.
- Reported industry data on banana prawn catches during the 4th and 5th week of the season.
- Tiger Prawn incidental catch in the 4th and 5th week of the season only.

### 6.1.3. Fishery monitoring

1. A fishery-wide Daily Catch & Effort logbook program for banana prawns.
2. Reported industry data on banana prawn catches in the first (banana prawn) fishing season.
3. Reported industry data on tiger prawn catches in the first (banana prawn) fishing season.
4. An annual fishery independent data collection program based on two modules:
   - a January/February survey which provides data for a fishery independent recruitment index for banana, tiger and endeavour prawns;
   - a June/July survey which provides information on the spatial distribution of the fishery.
5. Seasonal Landings Returns.
6. Economic data collected by ABARES.

### 6.1.4. Fishery reference points (abundance indicators)

1. An average catch rate across the fleet of no less than 500 kg per day per vessel at the end of the 5th week in the banana prawn fishing season.
2. A trigger limit of 6.6 t/week of tiger prawns caught at the end of the 5th week in the banana prawn fishing season.
3. An average catch rate across the fleet of no less than 500 kg per day per vessel at the end of the 7th week of the banana prawn fishing season.
4. An average catch rate across the fleet of no less than 500 kg per day per vessel at the end of the 9th week

### 6.1.5. Method of assessment

There is currently no formal stock assessment for banana prawns, however a study is underway. The variability of this resource means no clear stock-recruitment relationship can be determined and catch rate data as an index of abundance is proving to be questionable (Vance *et al*. 2003; Rothlisberg *et al*. 2006). Analyses are complicated by the highly-variable CPUE data which result from the schooling behaviour of the

species. However, work by Zhou *et al*. (2007) in which the catches from the fishery were modelled as outcomes of an overdispersed Bernoulli process, provides an approach that may potentially resolve the difficulty of relating CPUE data to the abundance of the white banana prawns and thereby may enable the development of a model that can be used for stock assessment of this species. A study that related regional environmental variables with catch has shown some promising results to set a TAC for common banana prawns (Venables *et al*. 2011). A follow up project has been developed to further refine this method of predicting the white banana prawn catch. In addition this project will develop the principles of setting a TAC that moves the fishery towards MEY, as required in the harvest policy.

The fishery is currently controlled by a fixed season length with in-season management aimed at potentially closing the season earlier to increase the economic return to the fishery in less productive years. Historical records indicate that the banana prawn fishery is sustainable with an annual six week fishing season. The high variability and environmental dependency of this species results in significant variations in catch from year to year, and even in the years where there have been very poor catches in some areas, the rebound in the stocks would indicate that the banana prawn fishery is resilient. The reduction in fleet size in 2006/7 reduced the ability of the fleet to search for and catch white banana prawns to the same extent they have done in the past.

The 500 kg per day per boat catch indicator described in the decision rules below is the criteria used to determine whether the season will close early in less productive years. This catch indicator was derived by taking an average of the catches of the fourth fishing week in the most productive banana prawn seasons over a ten year period and divided by the number of boats.

The tiger prawn season commences on 1 May in each year, prior to this there are spatial closures in place to protect tiger prawns and there is an industry agreement to minimise the targeting of tiger prawns during this time. There is limited incidental catch of endeavour or king prawns during the period that the banana prawn season is open.

The NPFI analyses industry catch reports after the fifth fishing week to determine which of the following decision rules are to be applied.

The white banana prawn fishery is presently managed by spatial and temporal closures. The first season will not start before 15th March and will not extend beyond 15th June. It should be noted that the mid-season closure is mainly a measure to protect spawning tiger prawn females, but is likely to benefit the sustainability of all target species.

### 6.1.6. In-season management: decision rules for early closure of the first season

The first season (banana prawn season) extends for 12 weeks from the start of the season, unless the following decision rules are triggered:

***1st Possible Season Closure (6 week season)***

EITHER

(a) If the average daily catch rate of banana prawns for the 4th and 5th weeks of the first season is less than 500 kg/boat/day;

OR

(b) If the pro-rata total tiger prawn catch for the whole 5 weeks is more than 33 tonnes (6.6 t/week*5);

THEN

(a) The fishery is closed at the end of the 6th week from the start of the first season. To facilitate the assessment of whether an early closure to the season is appropriate based on the decision rule, a "representative sample" of the catch rates for the season across the fleet is required.

The decision rule can only be applied if all catch data (kg/day, or total catch and total days) for the whole fleet (or >95% of NORMAC members and advisors) is supplied for the period of the 4th and 5th weeks of the season by 3 days after the end of that week. If the data is not provided, the season will close at the end of the 6th week.

**Reporting Requirements**

This information can take the form of:

EITHER

(a) Providing a copy of the logbooks from each boat fishing for weeks 4 and 5, which shows the catch of banana prawns per day fished;

OR

(b) Providing company records indicating the total catch of banana and tiger prawns for weeks 4 and 5 and the number of days fished per boat during those weeks.

**2nd possible season closure period (8 week season)**

IF

(a) If the average daily catch rate of banana prawns for the 6th and 7th weeks of the first season is less than 500 kg/boat/day;

THEN

(b) the fishery is closed at the end of the 8th week from the start of the first season.

To facilitate the assessment of whether an extension to the season is appropriate based on the decision rule, a "representative sample" of the catch rates for the season across the fleet is required.

This decision rule can only be applied if all catch data (kg/day, or total catch and total days) for the whole fleet (or >95% of NORMAC members and advisors) is supplied for the period of the 6th and 7th weeks of the season by 3 days after the end of that week. If the data is not provided, the season will close at the end of the 8th week.

**Reporting Requirements**

This information can take the form of:

EITHER

(a) Providing a copy of the logbooks from each boat fishing for weeks 6 and 7, which shows the catch of banana prawns per day fished;

OR

(b) Providing company records indicating the total catch of banana prawns for weeks 6 and 7 and the number of days fished per boat during those weeks.

**3rd possible season closure period (10 week season)**

IF

(a) If the average daily catch rate of banana prawns for the 8th and 9th weeks of the first season is less than 500 kg/boat/day;

THEN

(b) the fishery is closed at the end of the 10th week from the start of the first season.

To facilitate the assessment of whether an extension to the season is appropriate based on the decision rule, a "representative sample" of the catch rates for the season across the fleet is required.

This decision rule can only be applied if all catch data (kg/day, or total catch and total days) for the whole fleet (or >95% of NORMAC members and advisors) is supplied for the period of the 8th and 9th weeks of the season by 3 days after the end of that week. If the data is not provided, the season will close at the end of the 10th week.

**Reporting Requirements**

This information can take the form of:

EITHER

(a) Providing a copy of the logbooks from each boat fishing for weeks 8 and 9, which shows the catch of banana prawns per day fished;

OR

(b) Providing company records indicating the total catch of banana prawns for weeks 8 and 9 and the number of days fished per boat during those weeks.

**4th possible season closure period (12 week season)**

IF

(a) If the average daily catch rate of banana prawns for the 10th and 11th weeks of the first season is less than 500 kg/boat/day;

THEN

(b) the fishery is closed at the end of the 12th week from the start of the first season.

To facilitate the assessment of whether an extension to the season is appropriate based on the decision rule, a "representative sample" of the catch rates for the season across the fleet is required.

This decision rule can only be applied if all catch data (kg/day, or total catch and total days) for the whole fleet (or >95% of NORMAC members and advisors) is supplied for the period of the 10th and 11th weeks of the season by 3 days after the end of that week. If the data is not provided, the season will close at the end of the 12th week.

**Reporting Requirements**

This information can take the form of:

EITHER

(a) Providing a copy of the logbooks from each boat fishing for weeks 10 and 11, which shows the catch of banana prawns per day fished;

OR

(b) Providing company records indicating the total catch of banana prawns for weeks 10 and 11 and the number of days fished per boat during those weeks.

## 6.2. Red-legged banana prawns

Although both white and red-legged banana prawns are caught west of 129.3567° longitude and south of 12° latitude (the JBG box) for practical purposes all banana prawns caught within this region will be considered to be red-legged banana prawns. In reality, on average, 16% of the NPF total white banana prawn and 65% of the NPF total red-legged banana prawn catches are caught in the JBG region (Dichmont *et al.* 2010).

### 6.2.1. Fishery Monitoring

1. A fishery-wide Daily Catch and Effort logbook program for Banana Prawns.

2. Seasonal Landings Returns.

3. Economic data collected by ABARES.

### 6.2.2. Reference and Trigger Points and Decision Rules

An assessment model is available for red-legged banana prawns. It is a quarterly age-based biological model with no economic component internal to the model (in contrast to that for the Tiger Prawn fishery). For red-legged banana prawns, the LRP proxy (as per the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines*) of $0.5B_{MSY}$ is used. The overfishing reference points are the corresponding fishing mortality levels that correspond to the above over the long-term. The assessment model was used to interpret the limit reference point as kilos of catch. The assessment model computed that the limit reference point of $0.5B_{MSY}$ was equal to 390 kg/day.

The red-legged banana prawn assessment is much less certain than the Tiger and Endeavour assessments. Because there is no pre-season survey, the assessment relies on CPUE data only and the standardisation of these data may be less reliable than that applied to the other species which have been subject to longer and more in-depth analyses. The confidence limits for the estimates of stock size are broad. As a result, the red-legged banana prawn LRP does not align with the Tiger and Endeavour prawn LRP. The Tiger and Endeavour prawn LRP is based on the value of the five year moving average of $S_Y/S_{MSY}$ (where 'S' is stock size). For red-legged banana prawns the LRP is triggered as soon as the stock falls below $0.5B_{MSY}$ for two years in a row. Since the model relies on fisheries dependent data, some provision for collecting catch rate data may be required. For the same reason, the fishery would be re-opened after a single year closure in order to maintain reliable data for the stock assessment. Historically, the stock has only dropped below this level once, during the years 1997-1999.

The following reference points will be used in the management of the red-legged banana prawns:

1. A LRP of 390 kg CPUE.

2. Undertake the annual stock assessment using the natural mortality rate of 0.05 per week (based on tagging data from Die *et al*. 2002) with a co-management and NPRAG-agreed season pattern and using standardised CPUE data.

3. Catch data from the JBG fishery will be analysed for the period from August, September & October inclusive at the end of each calendar year.

4. If a minimum of 100 fishing days has been achieved *and* the red-legged banana prawn stock size falls below the LRP for the two most recent consecutive years, then the TAE is zero for a year (no fishing in the following year).

5. After one year, the TAE for the subsequent year would be set at a precautionary level based on the stock assessment model-predicted TAE. The option to use research effort to maintain catch rate data for the assessment could be considered.

6. Else if the LRP is *not* triggered, then:

7. Fishing **WILL** be allowed for the full two seasons in the following year provided:

   - that data has been provided for a minimum of 100 fishing days over the full fishing year *AND*
   - that the average catch per boat per fishing day in August, September & October is 390 kg or more.

8. Fishing **WILL** be allowed for the full two season in the following year:

   - if data has been provided for less than 100 days of fishing during the full fishing year *AND*
   - whether or not the LRP of 390 kgs per boat per fishing day in August, September & October has been triggered.

9. Fishing will **NOT** be allowed in the first (banana prawn) season of the following year:

   - If data has been provided for a minimum of 100 fishing days over the full fishing year *AND*
   - that the average catch per boat per fishing day in August, September & October is less than 390 kg;
   - however the fishery will be re-opened to fishing in the second (tiger prawn) season of the same year.

The fishery (when fishing is allowed) will open at the same time as the rest of the NPF however the fishery will close if the catch trigger limits/decisions rules in place for the white banana prawn and tiger prawn fisheries close the rest of the NPF in any given season.

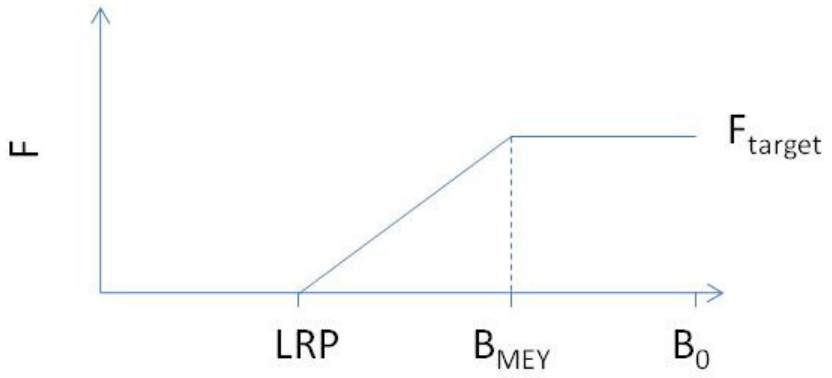


**Figure 7: Stylised diagram showing the "hockey stick" rule as described in points 2 and 3 above. LRP is limit reference point, F fishing mortality and $F_{target}$ here is $F_{MEY}$ the fishing mortality at MEY. $B_{MEY}$ is the biomass at MEY and $B_0$ is the unfished or virgin stock size.**

# 4. OTHER TARGET SPECIES AND BYPRODUCT

## a. Scampi

There is no current formal stock assessment for Scampi.

Scampi is taken from a deepwater area on the edge of the AFZ north of Melville Island and is targeted during NPF prawn trawling closure periods. An average of only six NPF trawlers (less than 5% of the total NPF fleet)[4] has targeted scampi each year. This is a result of the high cost associated with travel to and from the scampi grounds, and the restricted market opportunities for sale of the catch. Average scampi catches from 2005 to 2009 were 12 t per annum.

Historically, the total number of fishing days spent targeting scampi has been generally static (within 10%). Given the low catches of scampi and the small number of boats which take scampi the species is considered to be ecologically sustainable and it is likely, given the recent NPF restructure, that even fewer boats will fish for scampi in the foreseeable future.

### i. Decision Rules for Scampi

If in any year the total catch is > 30t OR the number of vessels involved is ≥8 vessels, then the next year there is a 30 t limit on the catch. This trigger will cause a review of the size structure of the catch, to assess a decline in animal size (commercial grades will be used to measure size change).

## b. Squid

Squid is a target species under the NPF Management Plan, however given the low volume and the low value of squid taken by NPF trawlers, this resource is treated as a byproduct in this Harvest Strategy. (Refer below)

## c. Byproduct

Byproduct refers to any part of the catch which is kept or sold by the fisher but which is not the target species. Specific harvest strategies have not been incorporated in this document for byproduct species. However, management controls (size/trigger limits) are in place for a range of byproduct species. In addition, as a number of byproduct species are taken as an incidental part of the tiger prawn catch, the effort controls which apply to tiger prawns also apply to these species.

The byproduct species which are incidentally caught in trawling operations and which are retained because of their commercial value include:

- two species of slipper lobster (bugs) (*Thenus indicus* and *Thenus orientalis*), also referred to as bay lobster are exploited in areas where prawns are targeted;
- one species of scallop (*Amusium pleuronectes*), or delicate saucer scallops – taken incidentally in the NPF in coastal waters off the Northern Territory, from around Melville Island to west of Karumba and an area around Weipa. Approximately 40% of NPF trawlers retain their catch of saucer scallops for sale (Pender and Willing 1990). Trawlers target resting (post-spawning) or pre-spawning adults when meat yield and scallop condition are at their best (Joll 1989);
- Squid (as noted) and Cuttlefish, Mud Crabs and Tropical Rock Lobster

[4] Fleet size at June 2006

- some larger fish species.

Byproduct limits or other management measures are in place for a large range of species (refer Table 1). These bycatch limits are implemented through Directions made under subsection 17 (5A) of the *Fisheries Management Act 1991 (*as amended).

A Fisheries Research and Development Corporation (FRDC) funded research project "Biology, dynamics and management strategy evaluation for byproduct species in the NPF" developed harvest strategies for byproduct species, including squid (Milton *et al.* 2010). This report calculated Allowable Biological Catches (ABCs) for major byproduct species, such as 306 t for Squid (the maximum catch between 2006 and 2010 was 175 t).

The NPF Harvest Strategy under Input Controls 2007 was amended in consultation with NORMAC to incorporate harvest strategies for byproduct species when they become available, and again updated in 2011 by NPRAG and NORMAC.

**Table 1: Byproduct limits and measures**

| **Species** | | **Catch Limit** |
|---|---|---|
| Shark, Skates & Rays (all species) | | NIL<br>No part of these species to be retained, including: fins, teeth, skin and sawshark beaks. |
| Narrow barred Spanish mackerel (*Scomberomorus commerson)*<br>Broad barred Spanish mackerel (*Scomberomorus semifasciatus)*<br>Longtail tuna (*Thunnus tonggol*)<br>Gold band snapper (*Pritipomoides multidens*) Coral Trouts, Rock Cods, Sea Breams etc (Serranidae family)<br>Sweet Lips (Lethrinidae family). | | 10 whole fish per trip |
| Mud crabs (*Scylla* species) | | 10 per trip |
| Tropical Rock lobster (*Panulirus ornatus*), also known as painted crayfish | | 6 lobsters or lobster tails per trip in total |
| Saddle tail snapper (*Lutjanus malabaricus*)<br>Red snapper (*Lutjanus erythropterus*)<br>Red emperor (*Lutjanus sebae*) | | (a) a total of 550 kg whole weight, 211 kg fillet weight, 500 kg gilled and gutted weight & 393 kg headed & gutted weight during the period beginning on 1 March in any year and ending 30 June the same year.<br>(b) a total of 55 kg whole weight, 22 kg fillet weight, 50 kg gilled and gutted weight & 40 kg headed & gutted weight during the period beginning on 1 July in any year and ending on 28 |

| **Species** | | **Catch Limit** |
|---|---|---|
| | | February in the same year. |
| Barramundi (*Lates calcarifer)*, Threadfin Salmon (*Polydactylus sheridani*), Blue Salmon (*Eleutheronema tetradactylum*), Black Jewfish (*Protonidea diacanthus*), Jewelfish or Yellow Jew (*Nibea squammosa*), Spotted Grunter-bream (*Pomadasys kaakan*), Queenfish (*Scomberoides lysan*; *S. commersonianus*), Pearl Shell (*Pinctada* spp.), Trochus (Class Trochidae), Trepang (Class Holothuridae), Coral | | NIL catch |
| Bugs (*Thenus indicus*, *Thenus orientalis*) | | • 60 mm minimum carapace;<br>• no berried female bugs;<br>• all bugs retained whole;<br>• no removal by any method (including chemical) of eggs from egg-bearing females; and<br>• 100 t trigger limit to review survey and logbook data |
| Squid | | • 500 tonne catch trigger limit;<br>• Review event at 300 tonnes;<br>• Appropriate management measures to be developed and implemented if catch trigger is reached. |

Note: If any of the above triggers are reached, the NPRAG needs, within that year, to consider the possible reasons and respond appropriately.

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