3 Introduction

3.1 Background and objectives

Harvest landings from the east coast Queensland trawl fishery are in the order of 10 to 13 kilo-tonnes annually and worth approximately $100–150 million dollars at the wharf. With 504 vessels licensed at the end of 2004, it is by far the largest prawn trawl fleet in Australia in terms of the number of vessels (Table 3.1). The fishery is complex in nature targeting several species of prawns (mainly *Penaeus* spp., *Meliceratus* spp., and *Metapenaeus* spp.), and mainly one species of scallop (*Amusium balloti*). It can be described as having identifiable sectors that are largely based on target species and geographic regions (Figure 3.1 and Appendix 14.1). In addition to this complexity, vessel characteristics continue to change through the adoption of new and better vessel technologies and fishing gear. Consequently, interpretation of the catch and effort statistics, monitoring the status of the fishery and the reviewing the suitability of management arrangements is more difficult.

Table 3.1 Comparison of licence numbers for prawn and scallop trawl fisheries in Australian jurisdictions.

Fishery	Number of licences
Australia's Northern Prawn Fishery	96
Western Australia	117
Spencer Gulf in South Australia	16
St Vincent's Gulf in South Australia	10
Torres Strait	88
Queensland	504

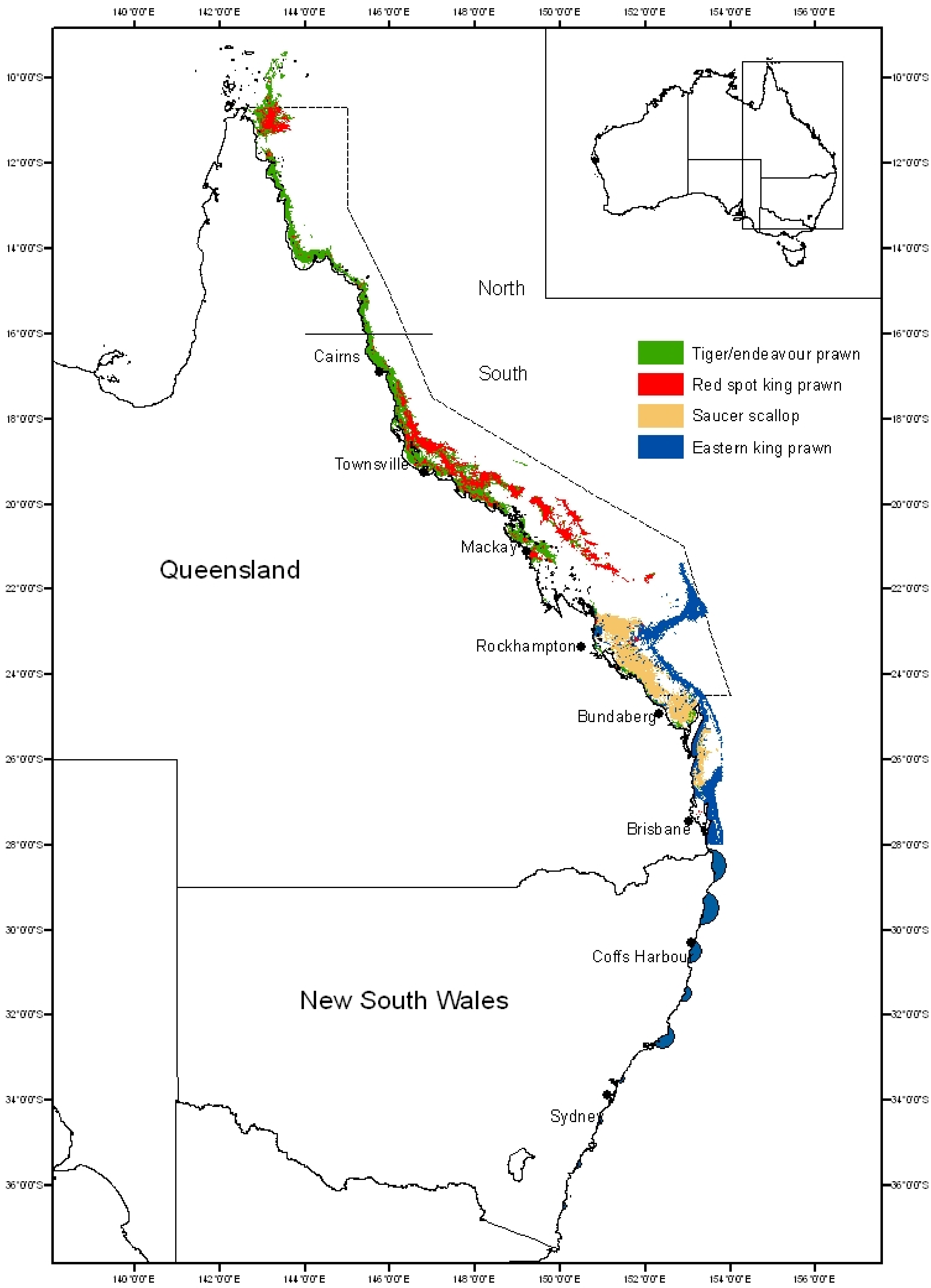

Figure 3.1 Spatial distribution of the trawl sectors harvest. The dashed line is the boundary of the Great Barrier Reef world heritage area. The horizontal line at 16˚S distinguishes the northern and southern tiger/endeavour prawn sectors. No high resolution vessel satellite data were available to illustrate the trawl sector in New South Wales; bubble plot of harvest at 1˚ degree of latitude intervals are shown.

In recent years the Queensland and Australian governments agreed to address Queensland's trawl fishing power increases by reducing fishing effort through the use of surrender provisions on licence and effort trading (Kerrigan et al. 2004). 'Fishing power' is the term used to describe the efficiency of an average vessel at catching prawns or scallops. Fishing power has varied over time and between trawl sectors (O'Neill et al 2005). In the lead-up to the revision of the *Fisheries (East Coast Trawl) Management Plan 1999* (the Plan) in 2001, the Premier's stakeholder working group suggested decreasing fishing effort by an annual rate of 3%. This rate was based on smaller fishing power increases than in the adjacent Northern Prawn Fishery (NPF, which extends from Cape Londonderry in Western Australia to Cape York Queensland); assuming that Queensland's east coast trawl vessels were less dynamic than NPF vessels in terms of technology change. The concept of reducing fishing effort according to potential fishing power increases was implemented to ensure that effective effort was capped in the fishery and to prevent effective fishing effort from increasing above the Great Barrier Reef World Heritage Area effort cap. The Great Barrier Reef World Heritage Area effort-cap was implemented in 2001 as 2.264471 million 'notional effort units' and was reduced in line with effort creep by 3% annually in 2002 and 2003 (Kerrigan et al 2004).

In 2003, the effects of improvements in fishing gear and technology on prawn and scallop catches from the east coast Queensland trawl fishery to 1999 were first published (O'Neill *et al.* 2003). For the 11-year period from 1989 to 1999, fishing power increased for an average vessel by 3% in the saucer scallop sector, 6% in the north Queensland tiger prawn sector, 5% in the eastern king prawn deep sector (in water depths greater than 50 fathoms), and 27% in the eastern king prawn shallow sector (in water depths less than 50 fathoms). These estimates equated to an annual rate of increase in fishing power ranging from 0.3% to 2.5% between 1989 and 1999. The rates of increase were largely attributed to vessels upgrading to larger engines and increases in the number of vessels using global positioning systems and computer mapping software.

During 2003 and 2004, the Department of Primary Industries and Fisheries (DPI&F) resource management group reviewed fishing effort in the east coast Queensland trawl fishery (Kerrigan et al. 2004). The review commented, based on the first fishing power estimates between 1989 and 1999 (O'Neill et al. 2003), that a value of 1% annual increase in fishing power be considered in assessing effort reductions in the Fishery. However, the review stated 'that this figure should be updated to reflect recent changes in the fishery and the impact that those changes have had on fishing power'. The recent changes they referred to was the change in the trawl fleet profile as a result of the trawl vessel buy back, licence and effort surrenders between 2000 and 2003. The report highlights a shift to a larger average hull unit (surrogate measure for vessel size representing the under deck volume of the boat) as a result of relatively more reductions in smaller vessels from the fleet.

This publication arose as management required estimates of changes in fishing power between 1988 and 2004 to:

- Standardise catch rates to assess the annual review events under the Plan.
- Quantify annual fishing power increases after fleet changes due to the introduction of the revised plan in 2001.
- Review specific penalty provisions as part of the review of the Plan in 2006.

General linear and linear mixed models were used to quantify marked fishing power increases since the previous estimates in 1999. These models were also used to calculate standardised catch rates, demonstrating that simple interpretation of raw catch rates can be misleading and mask declines or magnify increases in catch rates as a result of increasing fishing power.

3.2 Fishing power and standardising catches

Catch statistics are used as the basis of stock assessments in many fisheries. Trends in catch over time may reflect changes in the proportion of the population caught, changes in abundance of the target species, or both, owing to catch being a function of fishing effort and abundance of the fished population (Quinn and Deriso 1999). Stock assessments based on raw catch and effort data can produce biased predictions owing to efficiency changes in types and levels of fishing effort through time and between fishing operations or sectors. These biases can lead to a situation known as hyperstability, where catch rates may remain high even if fish stocks are being seriously depleted by increased fishing effort (Hilborn and Walters 1992) (Figure 3.2). There is, therefore, a need to standardise average catches, for example by employing a regression model (Hilborn and Walters 1992), to reduce the biases or variation in the data by accounting for factors affecting relative abundance and fishing efficiency. This results in a time series of catch and effort data that is more representative of trends in population abundance.

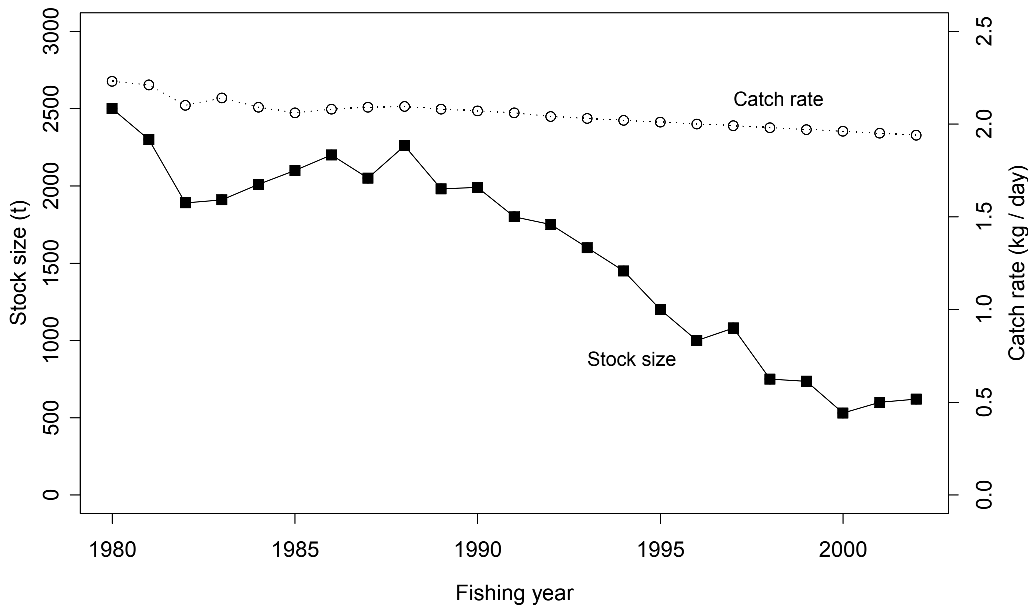

Figure 3.2 Hypothetical example of hyperstability between population (stock) size and catch rates; as stock size declines catch rates remain steady.

A number of studies have been published on standardisation of catch and effort data (Bishop et al. 2000; Bishop et al. 2004; Hall and Penn 1979; O'Neill et al. 2003b; Robins et al. 1998; Salthaug and Godø 2001). Generalised linear regression models (GLM) have been used to estimate changes in relative fishing power and to standardise average catches in the Queensland trawl fishery (O'Neill et al. 2003). They have also been used to quantify the effects of global positioning systems (GPS) on average catches in Australia's northern prawn fishery (Robins et al. 1998). Bishop et al. (2000) further developed the analysis of Robins et al. (1998) by using generalised estimating equations (GEE) to account for spatial and temporal correlations in the data. Furthermore, methods using linear mixed models (LMM) to analyse catches from Australia's northern prawn fishery were shown to produce reliable results compared to GLM and GEE analyses (Bishop et al. 2004). In contrast to the regression approach, Salthaug and Godø (2001) used a model for standardisation based on the relative fishing power between pairs of vessels fishing at the same time and place to estimate fishing power relative to a 'standard' vessel; see also Hall and Penn (1979). However, this method requires data with high spatial resolution and assumes that the chosen standard vessel's fishing power remains constant throughout the analysed period.

Standardisations of finfish catch and effort data have also been applied in a number of domestic and international fisheries. In southern Queensland, linear regressions were used to standardise commercial catch rates of yellowfin bream, dusky flathead, mullet, summer whiting, tailor and stout whiting (Dichmont et al. 1999; Hoyle et al. 2000; O'Neill 2000). In addition, a two component binary and truncated negative binomial model was used to analyse recreational catches from three estuaries in southern Queensland which validated improved measures of fishing effort to estimate total recreational catches (O'Neill and Faddy 2003a; O'Neill and Faddy 2003b). Internationally, logbook catches from tuna purse seiners were standardised using a regression model to make annual estimates of abundance adjusted for fishing mode, speed, capacity, use of aerial assistance, net dimensions and sea surface temperature (Allen and Punsley 1984).

3.3 The influence of management

The management of Queensland's east coast trawl fishery has become more complex in recent years. This section comments on the important changes in management that may have perceived impact on the statistics produced in this publication. For detailed management arrangements see Kerrigan et al. (2004) and QECTMP (2001).

Great Barrier Reef representative areas plan (spatial closures)

On 1 July 2004 the 'Great Barrier Reef Marine Park Zoning Plan 2003' was implemented (GBRMPA 2003). Since its implementation there is some perception that the spatial closures have had significant impact on prawn and scallop catch rates as collated through time (i.e. catch rates before and after the implementation are not comparable). Analysis of the trawl fishing effort displaced from the Great Barrier Reef Marine Park through these spatial closures was shown to be small at only 5.77% (Peel and Good 2004, report to the Australian Government; see also Hand 2003). The analysis used fine scale vessel monitoring system (VMS) location data and most of the displaced trawling was found to be on the banana and tiger/endeavour prawn sectors. Little impact was calculated on fishing effort from the saucer scallop and eastern king prawn sectors. No comments were made in the report on red-spot king prawns, but the impact on fishing in this sector was mostly likely included as tiger/endeavour prawn trawling. Any small bias in prawn and scallop catch rates caused by the spatial closures would be further minimised through the spatial factors in the statistical analyses.

Effort units

For many years, Queensland east coast trawl operators were discouraged from upgrading to more powerful vessels through a boat replacement policy, which required owners to purchase and surrender one additional license upon upgrading. This was commonly referred to as the two-for-one boat replacement policy. While effective at slowing the rate of increase in fishing power, it also had the detrimental effect of increasing the average age of the fleet (Glaister et al 1993). In 2001 this policy was replaced with effort units that are based on vessel allocated days and hull size as the principal means of limiting fishing effort. Effort units are defined as allocated fishing days × standardised hull units. In 2001 the total of individual vessel allocated fishing days was capped at 1996 levels as determined from submitted logbook returns (= 108346 days) (QECTMP 2001). Each vessel's standardised hull units were calculated by the following function:

$$SHU = 2.4052 \times HULLUNITS^{0.7617}$$

where hull units defined the size of the under deck volume of the vessel ($HULLUNITS = \frac{length \times beam \times depth \times 0.6}{2.83}$) (QECTMP 2001). Trawlers were limited to a maximum of seventy hull units unless approval was granted for a larger size. The standardised hull unit equation defined the relationship between fishing capacity (i.e. catch) and size of the vessel. It was developed by the CSIRO using catch data provided by the Queensland Fisheries Management Authority from only Princess Charlotte Bay (Dichmont et al. 2000; Kerrigan et al. 2004).

Penalties applied by the way of forfeiture of effort units are used to limit fishing power increases related to trading of effort units, licences and vessels. The transfer of effort units requires the licence holder to surrender ten percent of the effort units being transferred. The transfer of a trawl licence with attached effort units requires the licence holder to surrender five percent of the effort units transferred except in the case of a transfer from a deceased estate. In determining the effort unit penalty for vessel replacement a schedule is used which defines the number of effort units that are required to be surrendered for each sized boat (QECTMP 2001). Although the analyses focus on standardised catch-rates and fishing power of an average vessel-day in each fishing year, the results were adjusted according to effort units to calculate fishing power changes which allow for these penalty schemes (Appendix 14.3).

Effort reductions and the trawl buy-back scheme

The analyses conducted in this publication were based on average catches taken per vessel day. Therefore, any reduction in effort as a result of the trawl management plan, government trawl licence buy-backs and the 5% voluntary surrender of days by industry had no influence on the results. Compared to 1996, a total reduction of 19.4% (750 262) of allocated effort units or 28.8% (31 249) of allocated days was achieved by the end of 2003 (Kerrigan et al. 2004). As a result of the Australian Government's structural adjustment package for the Great Barrier Reef zoning a further 136 462 trawl effort units (= 21 licences) were purchased from the fishery in 2005 (personal communication: Queensland trawl manager June 2005). The analyses conducted here captured any change in fleet profile that may have occurred up to 2004 as a result of effort reductions.

Saucer scallops

The one sector where management changes do complicate the interpretation of catch trends is saucer scallops. Management of the saucer scallop fishery is through small spatial closures which commenced in April 1989 following concerns about the sustainability of the fishery (Figure 14.5). These closures were implemented for only seven months between April and October 1989 and are assumed to have negligible effect on the analyses as they were removed after ‘industry had shown unwillingness to comply with these closures’ (Queensland-Fish-Management-Authority 1989). As a result of declines in catch rates in 1996-1997, the closures were re-introduced in February 1997. The closures were generally referred to as ‘scallop replenishment areas’ and were fixed in place until 2001, when management, as a result of industry pressure, began a rotational strategy of opening and closing the areas to trawling (Figure 3.3). The minimum legal sizes of scallops have also varied historically. The minimum legal size was set at 80 mm in 1981. This changed to 85 mm in 1985. From 1988 to December 1999 minimum legal sizes were set at 90 mm from November to April and 95 mm for May to October inclusive. In January 2001 sizes changed to 90 mm from January to April, and 95 mm for May to December, inclusive. In November 2004 sizes changed to 90 mm from November 2004 to April 2005 and 95 mm for May 2005 to October 2005. The influence of changes in legal size limits on average catch rates is included in the fishing year and monthly trends from the analyses.

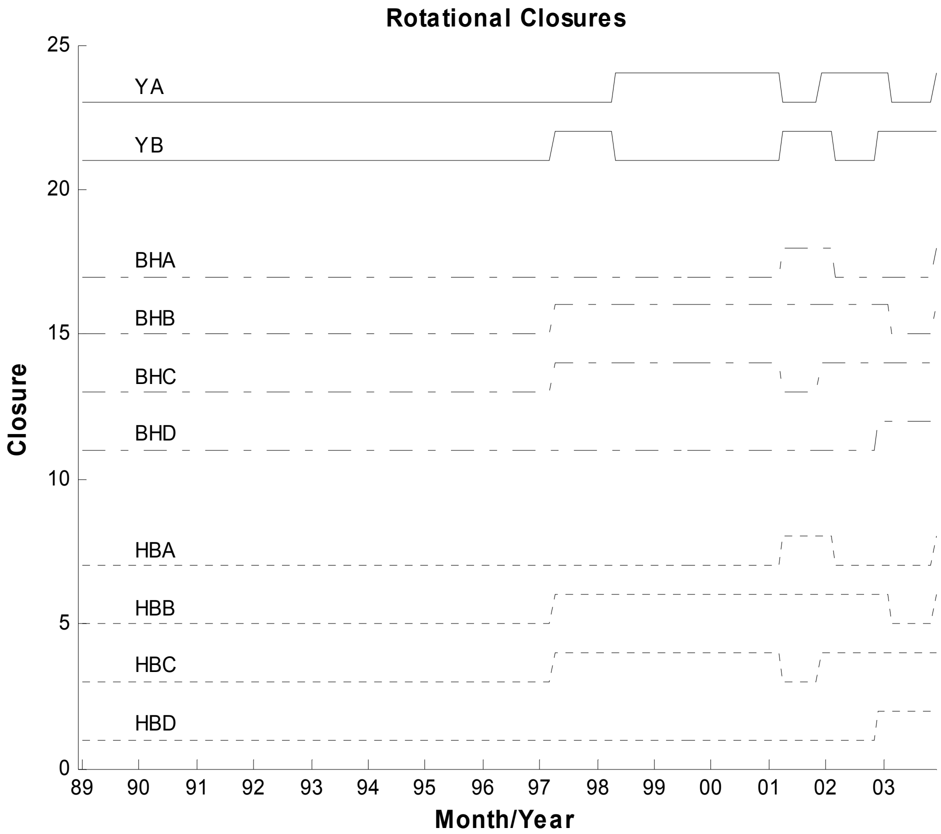

Figure 3.3 Application of fixed spatial closures in the scallop fishery commenced in 1997 and changed to a rotational closure strategy in 2001. The raised lines represent closure periods up to 2003. The closure definitions are Yeppoon (YA and YB), Bustard Head (BHA, BHB, BHC, and BHD), and Hervey Bay (HBA, HBB, HBC, and HBD). Since 2004 the closures BHA and BHB, BHC and BHD, HBA and HBB, and BHC and BHD were merged and rotations changed (Figure 14.5).