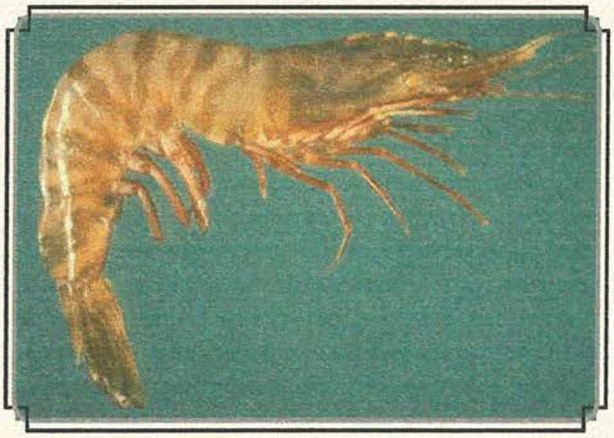
"Small Prawn Habitat and Recruitment Study"

(FRDC project 92/7)



Final report to the Fisheries Research and Development Corporation and the Queensland Fisheries Management Authority

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EXECUTIVE SUMMARY

We used simulation modelling to assess the Turtle Group strip closure to trawling in 1993 and 1994. We found:

- The strip closure provided only small benefits to the fishery in terms of catch value.
- The strip closure does, however, protect coastal seagrass beds which form an important commercial prawn nursery area.

We assessed the importance of deep water seagrass beds as commercial prawn nursery habitat in the Turtle Group region. We found:

- Deep water seagrass beds are not important nursery habitat for commercial prawns in the Turtle Group region.
- Coastal and estuarine seagrass beds are important nursery areas, particularly for the sought-after brown and grooved tiger prawns.
- Reef tops are important nursery areas for red spot king prawns.

We studied the recruitment of commercial prawns in the Turtle Group region through monthly trawl sampling for two years. We found:

- Commercial prawn recruitment in the Turtle Group region varied between years and between species.
- Long term (ten year minimum) data is required to make more confident assertions about recruitment variability.

We developed GFS (Geographical Fisheries System), an interactive, animated tool for visualising fisheries data. It is designed to assist in fisheries management decision-making by providing users with a better understanding of the fishery. GFS includes the following features:

- The facility to track the movement of objects through time on a map (eg tagging data).
- Thematic mapping functions such as displaying prawn densities at different sites through time.
- The facility to move closure lines and view differences between closure options.
- Although GFS was developed specifically for this project, it is flexible enough for much wider application.
- The PrawnEd educational module is also included with GFS.

RECOMMENDATIONS

- The Turtle Group strip closure to trawling should be maintained at approximately 10 m depth to protect coastal seagrass beds.
- Shallow coastal and estuarine seagrass areas should continue to be protected as crucial fisheries habitat.
- The importance of reef tops as nursery habitat for red spot king prawns should be recognised in the management and planning of the Great Barrier Reef Marine Park.
- Further research should be undertaken to determine the distribution of juvenile commercial prawns on seagrass beds in waters between 3 m and 10 m deep.
- Long term monitoring of the recruitment patterns of commercial prawns should be funded.
- Further development of GFS (Geographical Fisheries System) should be dependent upon feedback from users.
- If there is sufficient demand from users, PrawnEd should be expanded to include additional species and fishery information.

Table of contents

List of figures

List of tables

List of Abbreviations

CL	Carapace length
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPIQ	Department of Primary Industries, Queensland
ECTF	East Coast Trawl Fishery
FRDC	Fisheries Research and Development Corporation
GFS	Geographical Fisheries System
GPS	Global Positioning System
NORMAC	Northern Prawn Fishery Management Advisory Committee
QCFO	Queensland Commercial Fishermen's Organisation
QFMA	Queensland Fisheries Management Authority
VFRI	Victorian Fisheries Research Institute

Introduction

The East Coast Trawl Fishery

The Queensland East Coast Trawl Fishery (ECTF) is one of the most valuable fisheries in Australia, with an annual prawn catch of approximately 7000 tonnes (Trainor *et al.* 1992). The fishery is characterised by a large number of species, dramatic seasonal and annual fluctuations in abundance of resources, a large and mobile fleet, and a range of markets for product (Glaister *et al.* 1993). Effort is distributed along the entire Queensland east coast, but peaks in numbers of prawn trawlers occur in Moreton Bay and Princess Charlotte Bay, and near Rockhampton and Townsville (QFMA 1991).

Current management regime

The ECTF is managed by the Queensland Fisheries Management Authority (QFMA), and the primary management objective is to maintain biologically sustainable use of trawl resources (Glaister *et al.* 1993). A range of management measures are applied, including limits on vessel size and gear, limited entry licensing and both seasonal and spatial closures. Strip (spatial) closures to trawling may be designed to protect prawn nursery habitat (seagrass beds) and/or prevent growth overfishing (protect prawns until they reach optimal size, thereby maximising harvest value).

Why this study?

Strip closures: The debate

This project came about as a direct result of consultation with the fishing industry. Officers of the Department consulted with fishers at a series of Queensland Commercial Fishermen's Organisation (QCFO) and QFMA meetings in 1991 to determine the industry's view of trawl research priorities. The taking of "small" prawns, and in particular the effectiveness of strip closures in preventing the capture of "undersized" prawns, emerged as a controversial issue amongst the fleet. The most contentious strip closure identified was that in the Turtle Group region, some 250 km north of Cairns (Figure 1).

Two bodies of opinion emerged regarding the Turtle Group strip closure which are indicative of debate about strip closures in general. On one hand, fishers looked upon the closure as a barrier to an important fishery resource, namely a large biomass of small (but not valueless) prawns which should be caught before they die or disperse. Other fishers regarded the closure as a means of protecting a nursery area dominated by small prawns which "supplied" important fishing grounds to the south such as Cape Flattery (Figure 1). The primary thrust of this study was to settle this debate by determining the effectiveness of the Turtle Group strip closure.

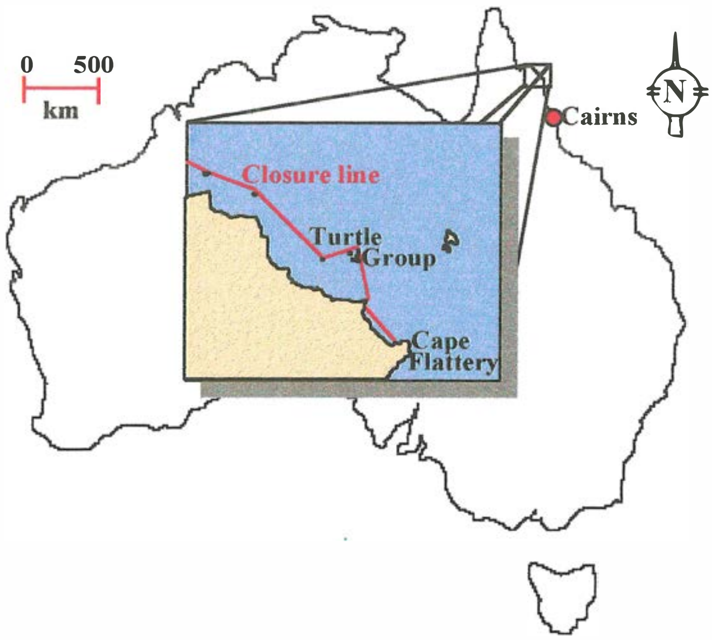

Figure 1. Study area.

Deep water seagrass: A vast nursery area?

The Turtle Group region has the largest known seagrass area - over 1500 km^2 of seagrass meadows which extend to the outer barrier reefs at depths of 28 m (Lee Long *et al*. 1993) - on the Queensland coast. The importance of shallow water (less than 10 m) seagrass beds as nursery habitat for commercial prawns has long been recognised, and strip trawl closures in north-east Queensland are largely based on the distribution of such beds. The role that deep water seagrass beds play in the life history of commercial prawns is not so clear. Working on the Turtle Group strip closure presented us with an opportunity to investigate this role by comparison with adjacent shallow water seagrass beds.

Designing fisheries software for the general user

Computer software is routinely used to analyse fisheries data. Simulation models such as Simsys (see *Simsys: A tool for closure assessment*) are useful tools for assessing closure options, but these packages are designed for specialist users. We saw a need for software though which a range of users - fishers, managers, scientists, students and the general public - could visualise fisheries data to develop a better understanding of management options such as trawl closures. While our design needed to focus on the Turtle Group strip closure, we also recognised that for software to have lasting value it should also incorporate sufficient flexibility for wider application. Our challenge was to develop user-friendly software that would make fisheries research data more accessible and help users to gain insight into some of the important processes that underlie fisheries management options.

Objectives

❶ Evaluate the relative importance and pattern of use of different seagrass habitats by juvenile commercial penaeid prawns.

❷ Study and describe the recruitment processes of penaeid prawns.

❸ Provide advice to managers on the best use of spatial closures.

❹ Develop an interactive, animated model that can be used as an educational and decision-support tool for managers and industry.

Juvenile prawns and nursery habitat

Objective ❶ | *Evaluate the relative importance and pattern of use of different seagrass habitats by juvenile commercial penaeid prawns.*

Summary

Deep water seagrass beds are not important nursery habitat for commercial prawns in the Turtle Group region. Coastal and estuarine seagrass beds are important nursery areas, particularly for the sought-after brown and grooved tiger prawns. Reef tops, including those with little or no bottom vegetation, are important nursery areas for red spot king prawns.

Recommendations

- Shallow coastal and estuarine seagrass areas should continue to be protected as crucial fisheries habitat.
- The importance of reef-tops as nursery habitat for red spot king prawns should be recognised in the management and planning of the Great Barrier Reef Marine Park.
- Further research should be undertaken to determine the distribution of juvenile commercial prawns on seagrass beds in waters between 3 m and 10 m deep.

Introduction

Seagrass beds form important nursery habitats for commercial prawns in many regions of northern Australia (Staples 1984, Coles *et al.* 1987). Juvenile prawns of different species may be associated with particular seagrass habitats. Coles *et al.* (1990) found that at Mornington Island in the Gulf of Carpentaria, brown tiger and blue endeavour prawns occurred mainly on subtidal seagrass, while western king prawns were found mainly on intertidal seagrass. Juvenile red spot king prawns were found on reef-top seagrass beds and on inshore seagrass beds situated in “reef like” environments in north-east Queensland waters (Coles *et al.* 1987). Such differences in the spatial abundance of juvenile prawns on seagrasses may influence the priority that managers give to protecting different seagrass areas (Coles *et al.* 1993).

Most of the work to date on the role of seagrass as prawn nursery habitat has focused on shallow water (less than 10 m deep) beds. The role that deep water seagrass beds play in the life history of commercial prawns is largely unknown. The Turtle Group region has a large area of deep water seagrass adjacent to and largely continuous with shallow water seagrass beds (Lee Long *et al.* 1993). We sought to establish the importance of these deep water seagrass beds as commercial prawn nursery habitat by comparison with the juvenile prawn catch on adjacent shallow water beds.

Methods

Preliminary survey

A preliminary survey was conducted in November 1992 using the 18-m research vessel "Gwendoline May" to determine trawlable ground (by use of sounder and trial trawl shots) in the study area. Reef tops and inshore areas were surveyed for seagrass by snorkel divers working from a dinghy to determine potential juvenile prawn sampling sites. The location of suitable safe anchorages was also taken into account when selecting sampling sites.

Sampling

A 1.5-m x 0.5-m beam trawl with 2-mm nylon mesh (Coles and Lee Long 1985) was used for sampling juvenile prawns. The 12.5-m research vessel "Lumaigul", or the "Gwendoline May", were used to tow the beam trawl on deep water sites. A 4.5-m dinghy was used on shallow water sites. Trawl duration on deep water sites was ten minutes, and a Global Positioning System (GPS) was used to estimate the distance towed. Shallow water sites were trawled along a 100-m transect marked at each end by buoys. Monthly sampling was carried out during 1993 at night near the time of the new moon to reduce any variation in catch rate associated with changes in moon phase. No samples were taken in April, June or July 1993 due to bad weather. Samples were placed in plastic bags, frozen and returned to the laboratory for processing.

An underwater video camera was towed on juvenile prawn sampling sites to record the bottom vegetation present. The duration of the video record was approximately five minutes for the deep water sites. The video was towed the length of the shallow water sites.

A small dredge (240 mm x 150 mm x 430 mm) was towed along the sea floor at each site for approximately two minutes to collect sediment samples for particle size analysis. Sediment samples were taken at the deep water sites 1 to 12 in June 1994, while the shallow water sites 13 to 17 were sampled in January 1995. Samples were frozen and returned to the laboratory for analysis.

Analyses

Penaeid prawns were identified and the carapace length (CL) of each was measured to the nearest 0.1 mm with dial callipers. The sex of sufficiently developed prawns was also determined. Prawns greater then 15 mm CL were considered too large to be juvenile and were excluded from analyses.

The cover of bottom vegetation was estimated from monthly video footage from September to December 1993. The video recording was paused at ten randomly set times during five minutes of playback for each site. The percentage cover of bottom vegetation was estimated each time the video was paused, and the estimates were averaged.

Sediment samples were dried and obvious organic matter removed by hand. A subsample of 100 g to 200 g was mixed with a 1% solution of Calgon to separate the particles. The subsample was then shaken through a series of sieves to segregate the particles into different size classes. We called particle sizes greater then 2 mm "gravel", those between 0.25 mm and 2 mm "coarse sand", between 0.063 mm and 0.25 mm "fine sand" and those smaller than 0.063 mm "mud".

Site description

Juvenile prawns were sampled from seventeen sites between Mid Reef and Lookout Point (Figure 2). Deep water sites 1 to 12 were located in depths between 13 m and 27 m. The inshore sites 13 and 15 were located in water 1 m to 2 m deep at high tide, while site 14 was located in a small creek about 100 m downstream of the mouth in water approximately 3 m deep. The reef sites 16 and 17 were located on the reef flat at Mid Reef in 1 m to 2 m of water at high tide. The types of vessels used precluded regular sampling in waters between 3 m and 13 m.

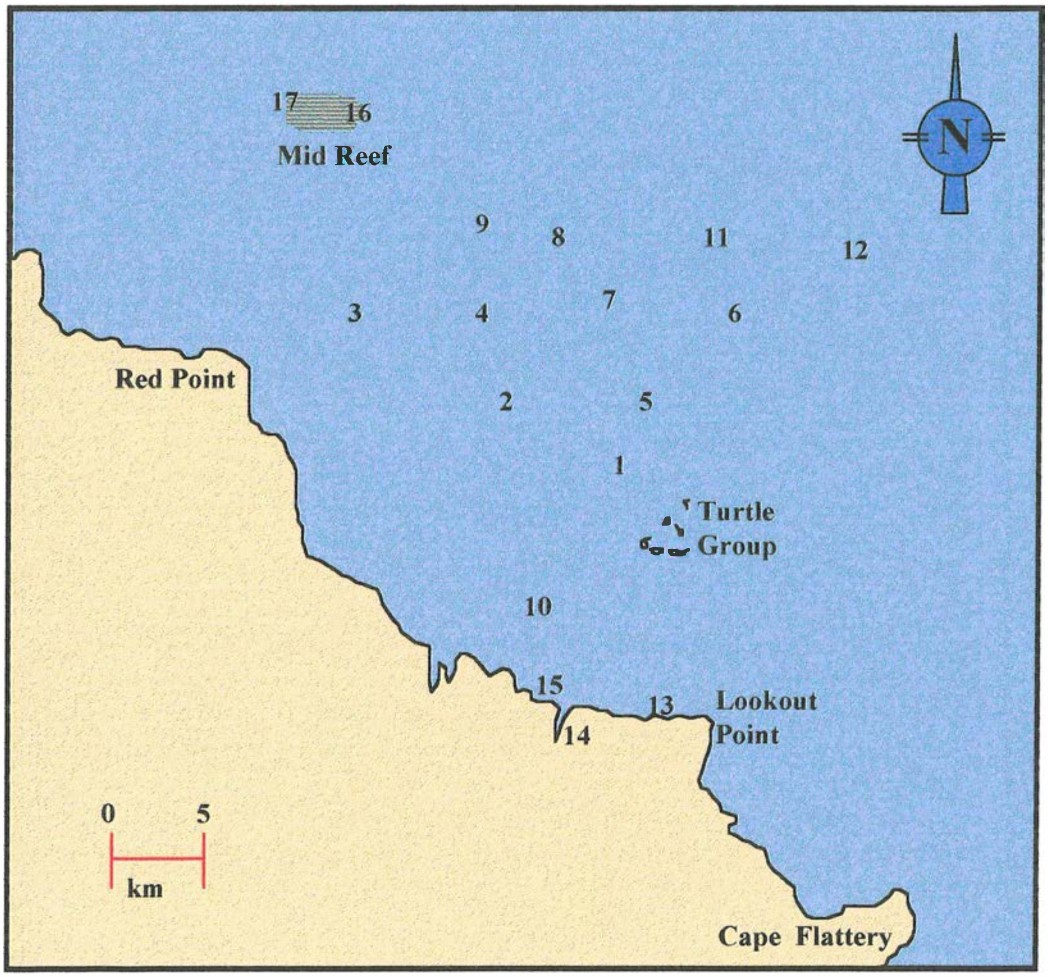

Figure 2. Juvenile prawn sampling sites.

Results & discussion

Seagrass

Seagrass beds on deep water and inshore sites were relatively dense, while reef-top sites were only sparsely vegetated (Figure 3). The seagrasses on deep water sites were primarily *Halophila spinulosa* and *H. ovalis*, and the seagrass-like algae *Caulerpa* sp. was also present. *Thalassia hemprichii* and *H. ovalis* made up the sparse seagrass cover on Mid Reef. The seagrass on inshore sites was mainly *Cymodocea serrulata* and *Halodule uninervis*.

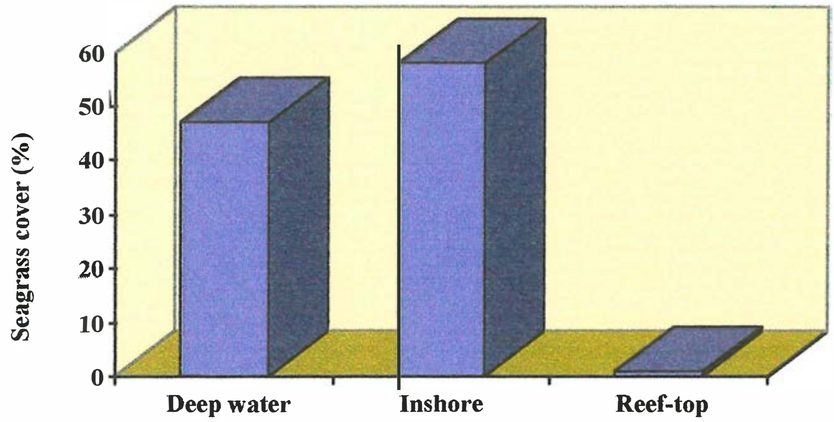

Figure 3. Average seagrass cover on reef-top, inshore and deep water sites.

Sediment

Deep water sites were the muddiest (Figure 4). Fine sand was the dominant sediment fraction on inshore sites, while reef sites were mainly course sand (Figure 4).

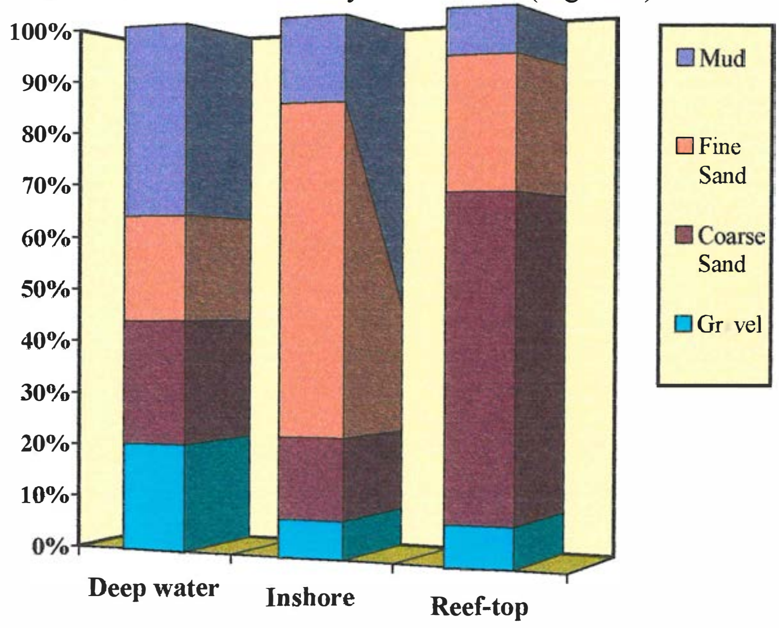

Figure 4. Sediment composition at inshore, reef-top and deep water sites.

Prawn species present

We found juveniles of nine commercial prawn species (Table 1).

Table 1. Commercial prawn species caught as juveniles.

Scientific name	Common name
Metapenaeus bennettae	Greentail prawn
M. moyebi	Western school prawn
M. eboracensis	York prawn
M. endeavouri	Blue endeavour prawn
M. ensis	Red endeavour prawn
Penaeus esculentus	Brown tiger prawn
P. latisulcatus	Western king prawn
P. longistylus	Red spot king prawn
P. semisulcatus	Grooved tiger prawn

We found juveniles of eight species (Table 2) which we considered non-commercial.

Table 2. Non-commercial prawn species caught as juveniles.

Scientific name	Common name
Metapenaeopsis lamellata	Hunchback coral prawn
M. mogiensis	Coral prawn
M. novaeguineae	Northern velvet coral prawn
M. palmensis	Southern velvet coral prawn
M. rosea	Rosy coral prawn
M. wellsi	Coral prawn
Sicyonia cristata	Ridgeback rock coral prawn
S. parvula	Coral prawn
Trachypenaeus curvirostrus	Southern rough coral prawn
T. granulosus	Hardback coral prawn

Comparing the catch on inshore, reef-top and deep water sites

Deep water seagrass, despite its vast area in the Turtle Group region, was not an important nursery habitat for commercial prawns. We found juvenile prawns on inshore seagrass beds at densities several thousand times greater than those on deep water seagrass beds (Figure 5). All juvenile prawns found on inshore seagrass beds, and 98% of juveniles found on the reef-top, were commercial species (Figure 6). In contrast, commercial species made up only 0.4% of the juvenile catch on deep water sites (Figure 6), and were represented by blue and red endeavour prawns only.

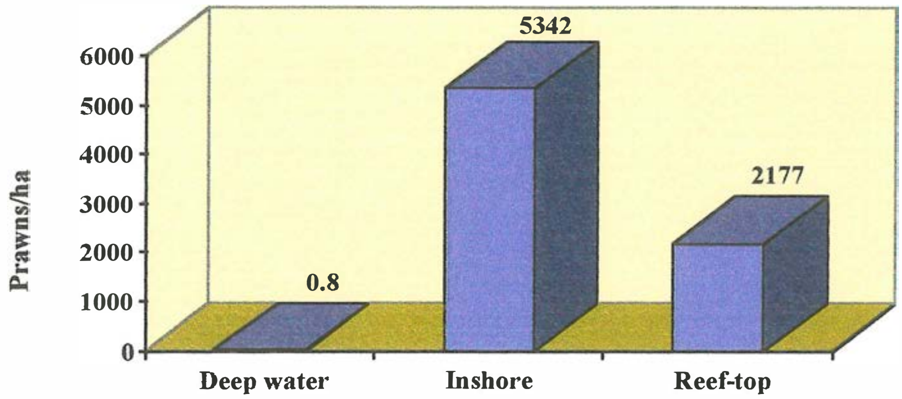

Figure 5. Juvenile prawn density on reef-top, inshore and deep water sites.

Juvenile tiger prawns were found only on shallow, inshore seagrass beds (Figure *6*). This emphasises the importance of such areas, as tiger prawns are the most valuable and sought after species in the fishery. Loneragan *et al.* (in press) found that juvenile brown tiger prawns around Groote Eylandt in the Gulf of Carpentaria were most abundant on seagrass beds in shallow coastal waters. Inshore seagrass beds were also the only area on which we found juveniles of "other commercial species" - greentail, western school and york prawns (Figure *6*).

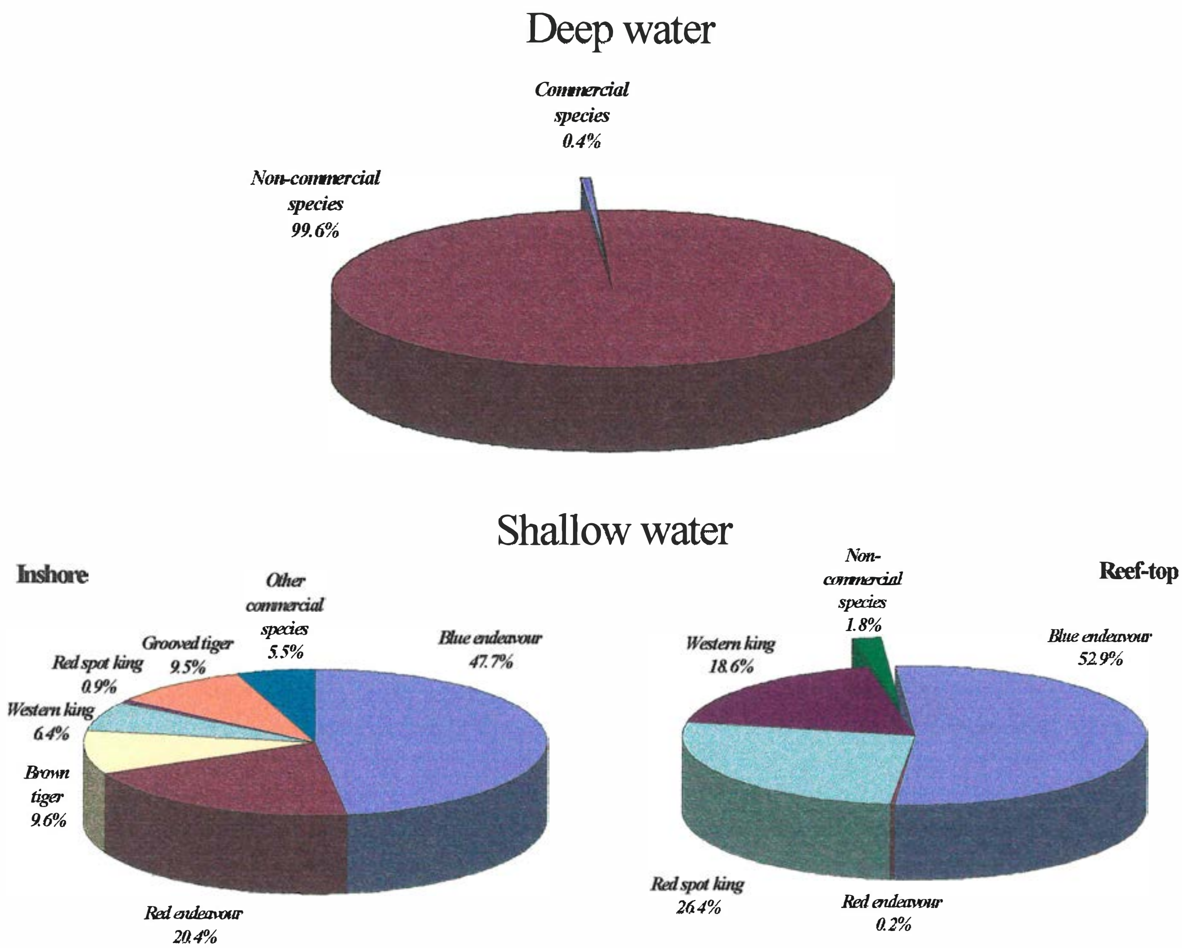

Figure 6. Juvenile prawn species composition on deep water, inshore and reef-top sites.

Blue and red endeavour prawns were found on all three sampling areas, and were the only commercial species present as juveniles on deep water seagrass beds (Figure 6). Blue endeavour prawns were the most common species on both inshore and reef-top sites, reflecting their large proportion in the fishery (see *Catch in the fishery*). Blue endeavour prawns were also the most common juvenile prawns found by Coles *et al.* (1987) between Cairns and the northern tip of Cape York, and by Derbyshire *et al.* (1992) in Princess Charlotte Bay.

While almost all juvenile prawns found on the reef-top were commercial species, only three species (red spot king, western king and blue endeavour prawns) were present in appreciable proportions (Figure *6*). The reef-top was an especially important nursery habitat for red spot king prawns, which were present in densities some ten times greater than those on inshore seagrass beds (Figure 7). Coles *et al.* (1987) also found juvenile red spot king prawns on reef-tops and on inshore habitats they considered “reef like”. Given the sparse cover of seagrass on Mid Reef (Figure 3), it is unlikely that bottom vegetation is necessary for the survival of juvenile red spot king prawns. Derbyshire *et al.* (1992) found a statistically significant relationship between the abundance of juvenile red spot king prawns and coarse sand sediments in Princess Charlotte Bay. Similarly, juvenile red spot king prawns were most abundant in our samples from sites with predominantly coarse sand sediment (the reef-top sites).

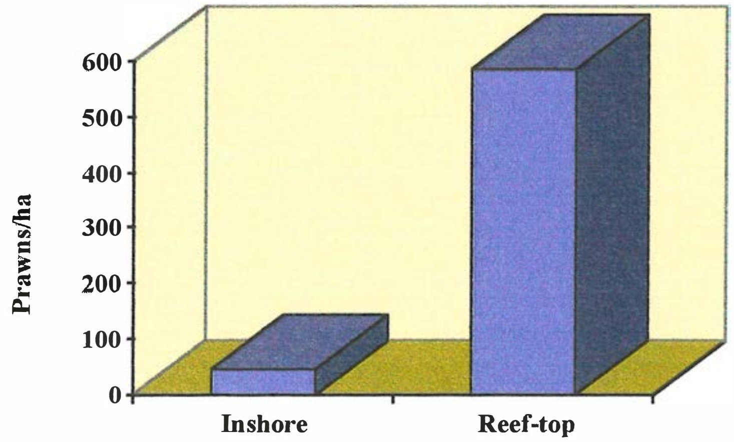

Figure 7. Density of red spot king prawns on reef-top and inshore sites.

Other commercial species such as brown tiger prawns have been found on reef platforms in Torres Strait (Turnbull *et al.* 1988), Princess Charlotte Bay (Derbyshire *et al.* 1992) and near Shelburne Bay (Coles *et al.* 1987), but these were all reefs with a far more dense seagrass cover than we found on Mid Reef.

Users of GFS (see *Geographical Fisheries System: Visualising fisheries data*) can view juvenile prawn species distributions through space and time in the Turtle Group region.

Juvenile prawns: Reflecting the fishery

All of the commercial species commonly caught in the Turtle Group region fishery were also found as juveniles. Blue endeavour prawns, the most numerous species in the fishery (see *Catch in the fishery*) were also the most numerous species caught as juveniles. Commercial species less commonly caught in the fishery such as white banana (*Penaeus merguiensis*), leader (*P. monodon*), striped (*P. canaliculatus*) and Japanese king (*P. japonicus*) prawns were not found as juveniles. This not only reflects the small proportion of these species in the commercial catch, but also the fact that we did not necessarily sample the preferred nursery habitat of such prawns. White banana prawns, for example, are usually associated with the muddy banks of mangrove-lined estuaries (Staples 1984). On the other hand, we found two commercial species (greentail and york prawns) as juveniles that we did not catch in the fishery. These species may be present in the fishery, but likely only in very small numbers.

How deep is a nursery area?

Our sites were distributed in either deep water (> 10 m) or very shallow water (< 3 m). The occurrence of juvenile prawns in these two areas was clearly different, but we gathered no information on the depths in between. We believe that research into the distribution of juvenile commercial prawns in depths between 3 m and 10 m should be carried out. Such information may be of great use in "fine tuning" spatial closures to protect commercial prawn nursery areas (see *Why the strip closure should be kept*).

Why deep water seagrass is important

Deep water seagrass beds in the Turtle Group region may not be important juvenile commercial prawn nursery habitat, but they do serve other significant functions. The Turtle Group deep water seagrass beds are important feeding areas for a large dugong (*Dugong dugon*) population (Lee Long *et al.* 1989). Green turtles (*Chelonia mydas*) also feed on seagrass (Lanyon *et al.* 1989). Seagrass beds are highly productive and play an important role in nutrient cycling (Hillman *et al.* 1989), and the large area of deep water seagrass in the Turtle Group region is likely to represent a substantial bank of nutrients. Seagrass beds also serve to minimise re-suspension of sediment.

Recruitment of commercial prawns

Objective ❷ Study and describe the recruitment processes of penaeid prawns.

Summary

Commercial prawn recruitment timing in the Turtle Group region varied between years and between species. Such variability may decrease the effectiveness of seasonal closures. Long term (ten year minimum) recruitment data is required to make more confident assessments of the effectiveness of closures.

Recommendations

- Long term (ten year minimum) monitoring of commercial prawn recruitment patterns should be funded.

Introduction

What is recruitment?

For this study, we defined recruitment as the stage at which commercial prawns become available to the fishery. According to this definition, prawns which are present on fishing grounds, but are too small to be caught by the fleet, are not recruits. An example of simple recruitment is when prawns arrive in the fishery as a single cohort during only one month of the year (Watson *et al.* in press). In some fisheries, however, recruits may arrive during different months and at different ages (Blyth *et al.* 1990).

Why study recruitment?

Prawn trawl closures are usually designed to prevent capture of prawns until they reach optimum size, thereby maximising harvest value. It is difficult to design and assess such management measures unless the recruitment characteristics of the fishery are known. Watson and Restrepo (in press) found that seasonal closures can improve yields up to 40% for prawn fisheries with only one recruiting cohort, but this was reduced to less than 7% if recruitment consisted of multiple cohorts. We used monthly recruitment data as a basis for our assessment of the Turtle Group strip closure (see *Simsys: A tool for closure assessment*).

Methods

Sampling in the fishery

The research trawler "Gwendoline May" was used to collect monthly prawn samples from sites inside the strip closure and in the fishery. The vessel was rigged with otter-board trawl gear (four 7.3-m "Florida Flier" nets) typical of the fishery. Two of the nets had conventional commercial-size mesh (50.8 mm) while the other two nets had 31.8-mm mesh.

Sites 1 to 27 were sampled during 1993, while sites 1 to 34, encompassing Noble Island and Cape Flattery, were sampled during 1994 (Figure 8). Each site was trawled for 1 nautical mile each month. Sampling was conducted just prior to the time of the new moon to eliminate any catchability changes related to the lunar cycle. Commercial prawn species were removed from the catch and frozen for transport to the laboratory. The sex, species and size of each prawn (CL measured to the nearest 0.1 mm) was determined in the laboratory.

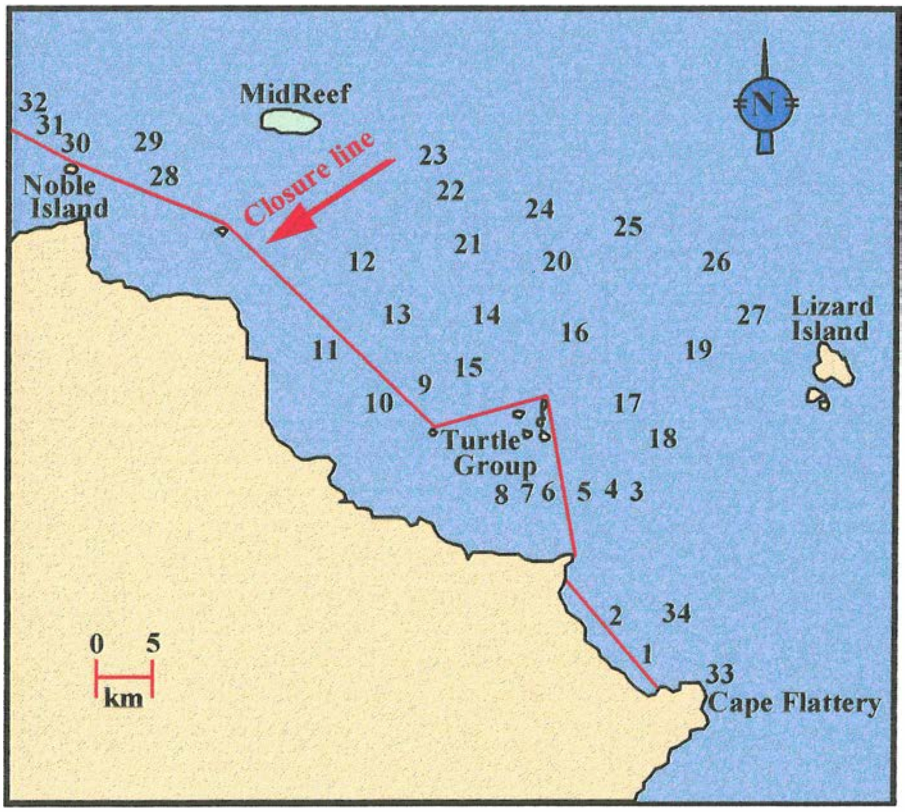

Figure 8. Prawn trawl sampling sites.

Estimating recruitment

Recruitment was modelled using the Age-Cohort recruitment identification method (Watson *et al.* in press) of the computer simulation model, Simsys. All recruitment patterns were modelled from length-frequency data collected inside the strip closure and were therefore not subject to modification by fishing pressure from the fleet (assuming the level of illegal fishing inside the closure was not significant).

Results & discussion

Recruitment variability: Implications for closures

Year to year variability in recruitment was substantial and occurred within species between years, and between species in the same year. Most female brown tiger prawns recruited in January of 1993 at four months of age (Figure 9). This was by far the strongest "pulse" of recruitment identified for any species. The following year, female brown tiger prawn recruitment was "smeared" across several months, with large proportions of five month-old prawns recruiting in April and June (Figure 9). January, the month of strongest recruitment in 1993, was a poor month for recruitment in 1994.

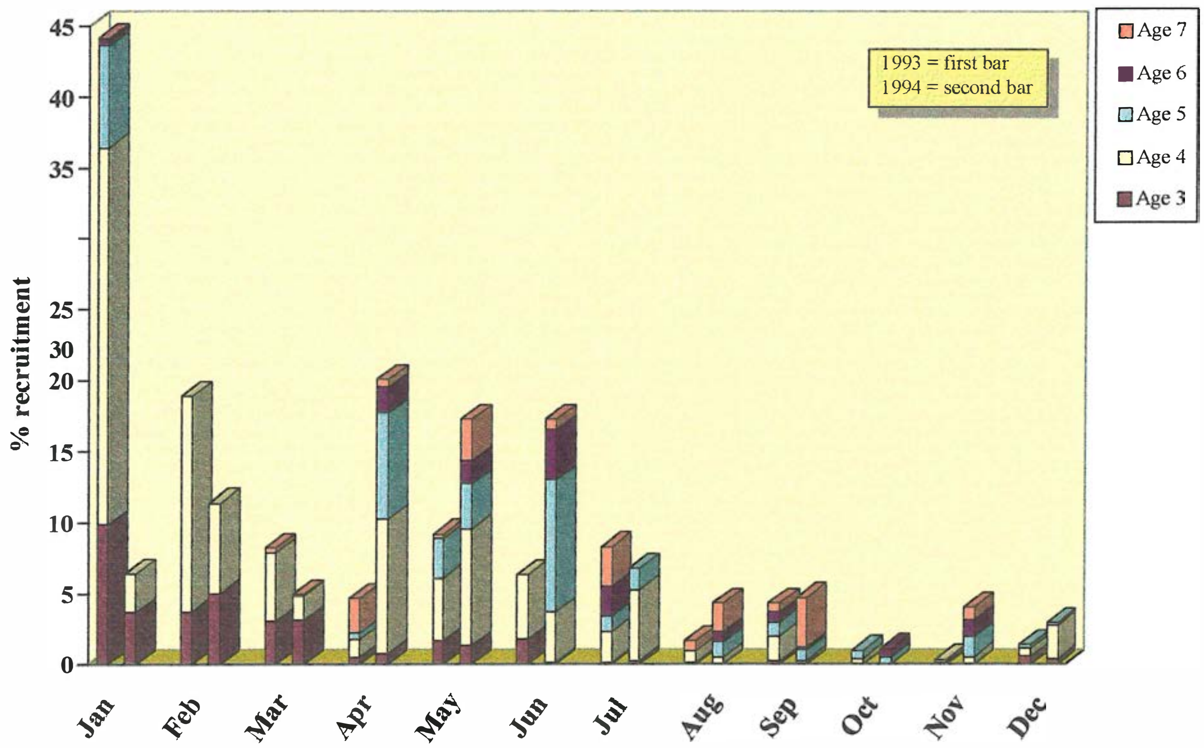

Figure 9. Female brown tiger prawn recruitment.

Peak recruitment of female blue endeavour prawns occurred in January and February 1993, but was greatest much later in the year in 1994 (Figure 10). In contrast to brown tiger and blue endeavour prawns, female grooved tiger prawns did not recruit strongly early in 1993. Recruitment for female grooved tigers peaked in April of 1993, and peaked even later in the year in 1994 (Figure 11). Recruitment for other species and for males also varied between years.

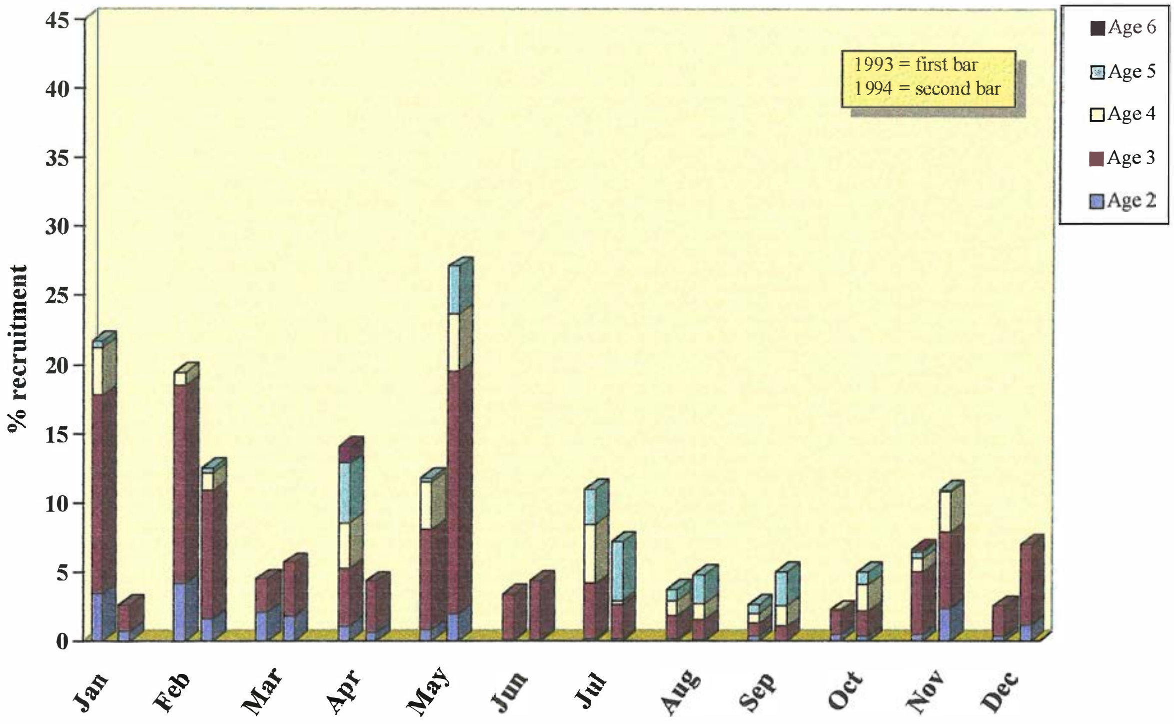

Figure 10. Female blue endeavour prawn recruitment.

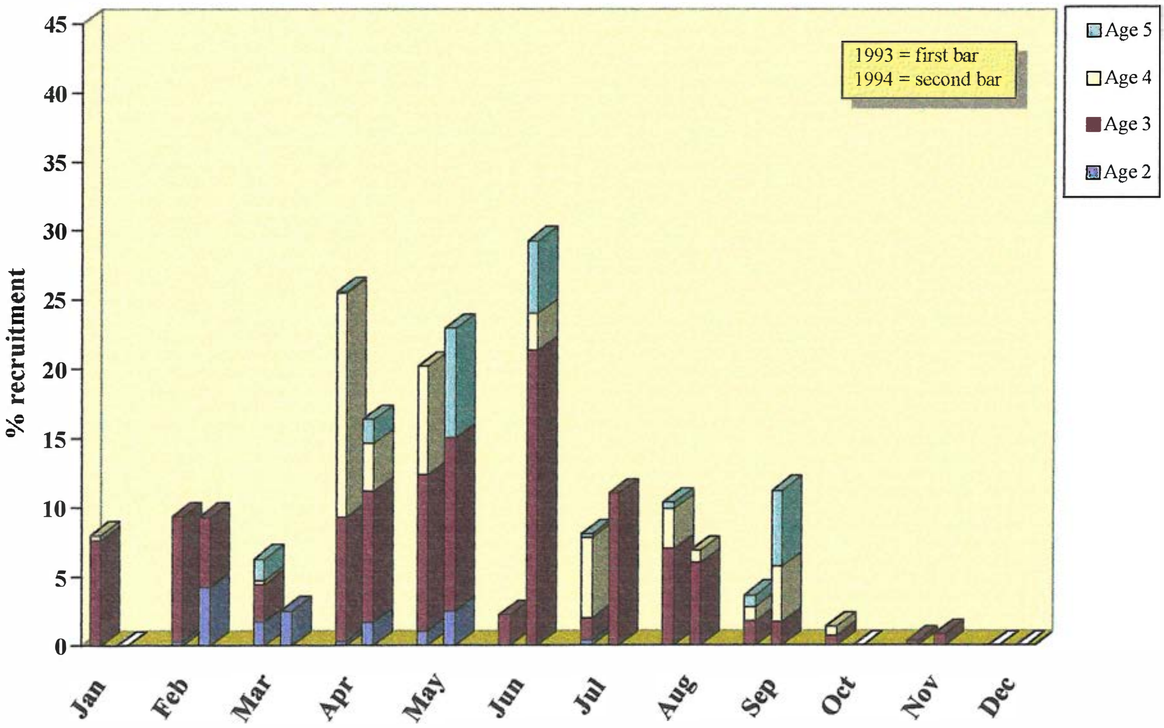

Figure 11. Female grooved tiger prawn recruitment.

Seasonal variability in recruitment has serious implications for seasonal closures. Seasonal closures work best when recruitment is simple and recruitment timing is consistent from year to year. Seasonal closures set in an environment of complex, variable recruitment are unlikely to be appropriate for all recruiting cohorts each year. Year-round strip closures are less likely to be effected by variability in recruitment timing than seasonal closures.

Although we identified strong variability in recruitment, we gathered only two years of monthly recruitment data. Without long-term recruitment data, it is difficult to judge whether 1993 or 1994 were representative of "typical" recruitment in the Turtle Group region, or represented opposite ends of a recruitment spectrum. Anecdotal evidence (in the form of fishers observations of a "late start" to the 1994 season) suggests that the generally later recruitment in 1994 may have been unusual. Given the differences in recruitment that we observed between two years, a data series in the order of ten years is required to make more certain conclusions about recruitment variability in the Turtle Group. It is likely that such data sets would also be required for other areas in the ECTF. To reduce the cost of collecting long-term data, a combination of logbook analysis, commercial catch sampling and limited research trawling could be undertaken.

The Turtle Group strip trawl closure

Objective ❸ Provide advice to managers on the best use of spatial closures.

Summary

The current Turtle Group strip closure protects coastal seagrass beds which form an important commercial prawn nursery area. The strip closure, however, provided only minor benefits to the fishery in terms of catch value (estimated by computer simulation of the closure in 1993 and 1994). Simulations predicted maximum benefits of 2% for closures set in shallow water. Predicted benefits decreased with increasing closure depth, but these differences were small. Minor adjustments to the current closure are likely to have only small effects on catch value.

Recommendations

- The Turtle Group strip closure to trawling should be maintained at approximately 10 m depth to protect coastal seagrass beds.

Introduction

Trawl closures in Queensland

Much of DPIQ's trawl research effort in recent years has focused on the assessment of closures. In particular, trawl closures in Moreton Bay (Courtenay *et al.* 1991), Bowen/Mackay (Gribble and Dredge 1994), Princess Charlotte Bay (Derbyshire *et al.* 1992), the Wide Bay Bar (Die *et al.* in press) and Torres Strait (Turnbull and Watson 1991) have been assessed. The basic objective of such closures, whether seasonal or spatial, is usually to prevent growth overfishing (the harvesting of prawns at sub-optimal sizes), thereby maximising harvest value. An effective closure provides a balance between preventing the capture of small prawns and allowing the capture of prawns before too many die of natural causes.

Not all prawns in the path of a trawl are caught and hauled on board. Many small prawns pass though the net, but may be damaged or killed in the process. Strip closures not only protect small prawns from capture, but also from damage or death as a result of passing through a trawl net. In addition, strip closures can be used to protect important habitat such as seagrass beds from damage caused by trawling.

Closures in the Turtle Group region

Strip closures to trawling in east coast waters north of Cairns were imposed in 1990. The objective of these "FNQ strip closures" was to "have areas of important seagrass beds and juvenile prawn nursery areas free from trawling for the conservation of stock and future industry benefits" (QFMA 1992). The current boundaries of the strip closure in the Turtle Group region were set in 1992, and waters inshore of the closure line (Figure 12) are closed to trawling year-round. Waters in the Turtle Group region are also subject to a seasonal closure to trawling of two to three months duration beginning around mid-December.

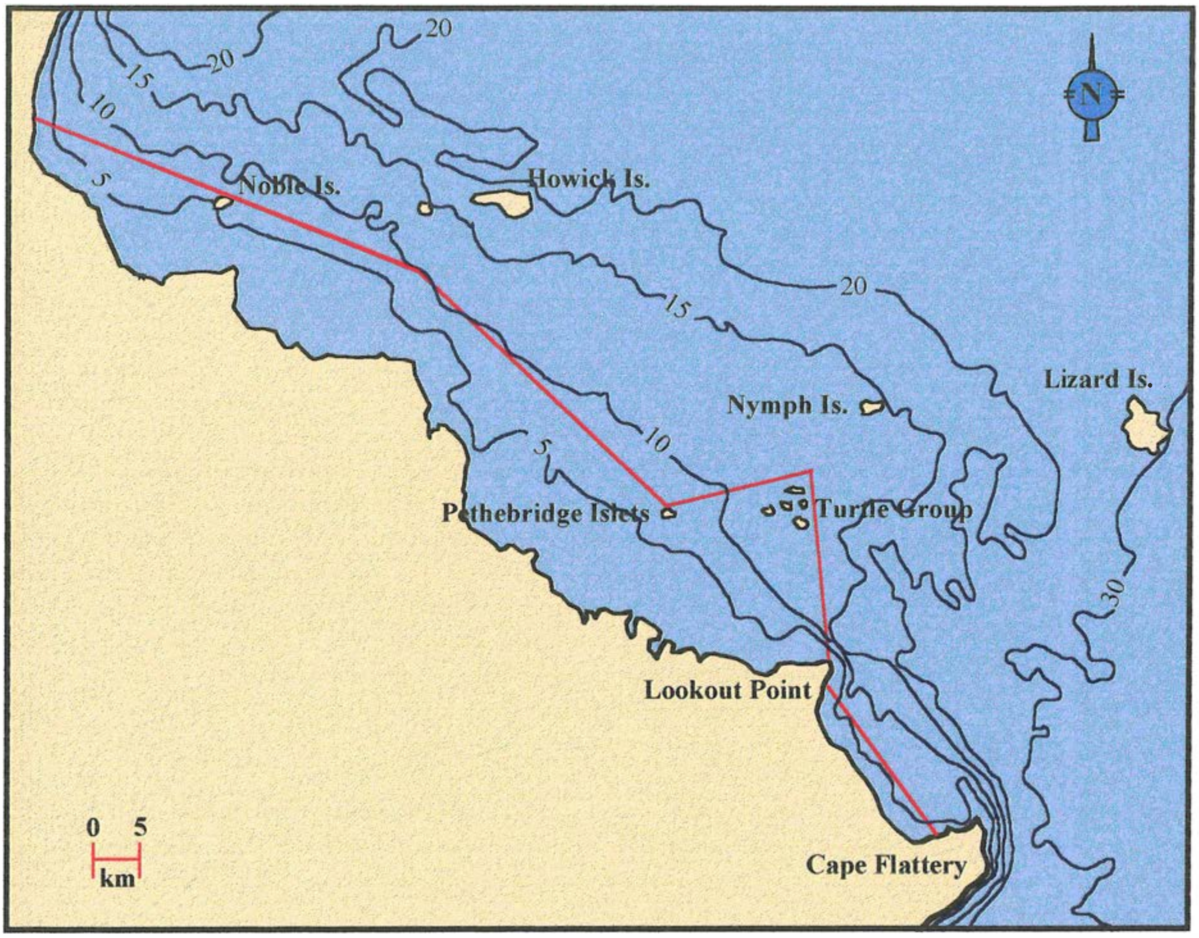

Figure 12. The strip closure and depth contours in the Turtle Group region.

We used simulation modelling to assess the effectiveness of the Turtle Group strip closure.

Methods

Prawn tagging

Prawn tagging methodology was similar to that described by Derbyshire *et al.* (1992). We tagged both brown and grooved tiger prawns. In January 1993, 5820 prawns were tagged and released from two sites within the strip closure (Figure 13). In January 1994, 6021 prawns were released from two sites inside the closure and one site outside the closure (Figure 13). Tagging was carried out during the seasonal closure of the fishery so that tagged prawns were at liberty for a minimum of four to six weeks before they could be recaptured by the trawl fleet. Trawl fishers were asked to return any tagged prawns they captured with details of capture location and date. A “tagged prawn lottery” with a prize draw at the end of each year was conducted to encourage fishers to participate in the tagging programme.

Logbook data

QFISH logbook data in 30’ x 30’ grids from Cape Melville to Cooktown were obtained from the QFMA. Monthly effort data for 1993 and 1994 from Cape Melville to Cape Flattery were included in simulations. This encompassed the area and period of our study.

Simsys: A tool for closure assessment

Simsys (Watson *et al.* 1993) is an age-based computer simulation model developed to assess both seasonal and spatial closures to multi-species prawn trawl (or similar) fisheries. The model produces estimates of the percentage change in key criteria induced by a range of closure options compared to a no-closure scenario. Parameter uncertainty is also incorporated, as the model can perform simulations with a range of values assigned to parameters. A Stock-Recruitment Relationship is not assumed in the model. It is important to appreciate that simulation models are not the “real world”, but represent our current understanding of the fishery using the best information available.

Recruitment information used in modelling procedures was limited to that collected from inside the strip closure and as such was unaffected by fishing. Data for brown and grooved tiger and blue endeavour prawns were included in simulations. Natural mortality and growth parameters were the same as those used by Derbyshire *et al.* (1992). Migration rates were estimated from regressions of depth against prawn size. Price information was collected from processors/buyers during the 1993 and 1994 fishing seasons. All percentage changes quoted in this report refer to changes in the total value ($) of the catch. We modelled closures based on depths of 5 m, 7.5 m, 10 m, 12.5 m and 15 m, which encompassed the depth range of the strip closure in the Turtle Group region (Figure 12).

Results & discussion

Prawn movement

Nearly all tagged prawns were recaptured south of where they were released (Figure 13). Recaptures were concentrated near Cape Flattery and, to a lesser extent, Cape Bedford, which are the main fishery areas south of the release sites. This movement pattern is evidence that the Turtle Group region is a major nursery and source of product for the fishery at Cape Flattery and further south. It is possible that some prawns moved north but were not recaptured, as fishing effort immediately north of the release area was lower than that to the south (Figure 15). However, Derbyshire *et al.* (1992) also found that there was very little northward movement of tagged brown tiger prawns in Princess Charlotte Bay.

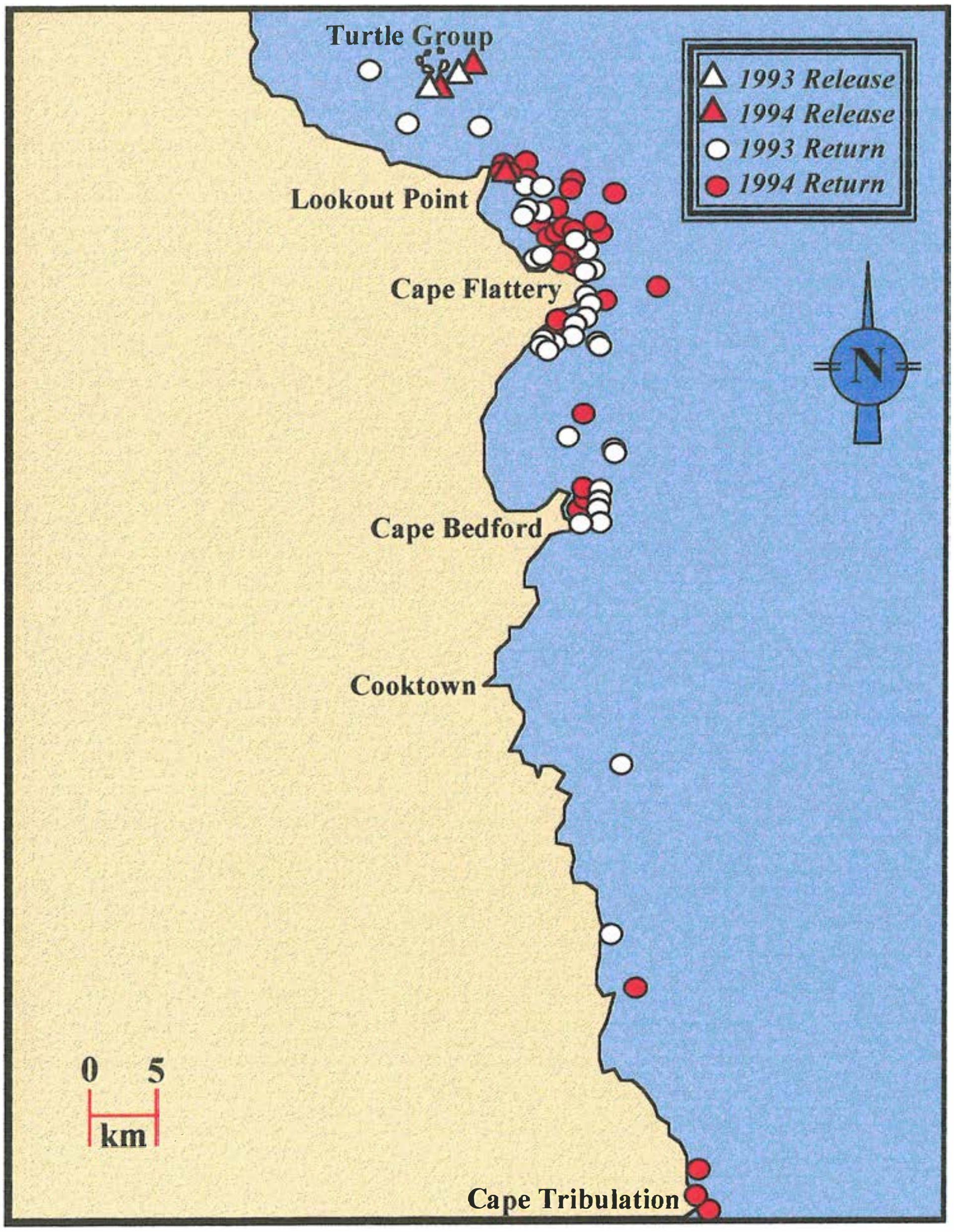

Figure 13. Tagged prawn release and return positions.

On average, tagged prawns moved 30 km before being recaptured, although the maximum distance moved was 85 km by a female brown tiger prawn released in 1994. The average speed of movement was 230 m day^{-1}. Users of GFS (see *Geographical Fisheries System: Visualising fisheries data*) can view an animated display of tagged prawn movement from this study.

Tagged prawn return rates

The return rates for this tagging programme were very low (just over 1%). In a similar tagging study in nearby Princess Charlotte Bay, the return rate for brown tiger prawns was approximately 9% (Derbyshire *et al.* 1992). There are many potential reasons for a low return rate. It is possible that some tagged animals stayed inside the closure (where the fleet should not fish), as the return rate from prawns released there (0.4%) was lower than for those released in the fishery (2%). Derbyshire *et al.* (1992) found that 45% to 76% of brown tiger prawns tagged in Princess Charlotte Bay made no net movement before recapture. Tagged prawns may have moved to areas with little or no fishing effort (Figure 15). It is also possible that despite the incentives we offered, some fishers did not cooperate and chose to keep recaptured tagged prawns.

Effort in the fishery

Fishing effort was distributed similarly through time in both years. Effort was greatest at the beginning of the season (the seasonal closure of the fishery was in effect from mid-December to 1 March) and decreased by about 30% in the following month (Figure 14). There was a mid-year (June/July) “slump” in effort, and relatively little effort in the later part of the season (Figure 14).

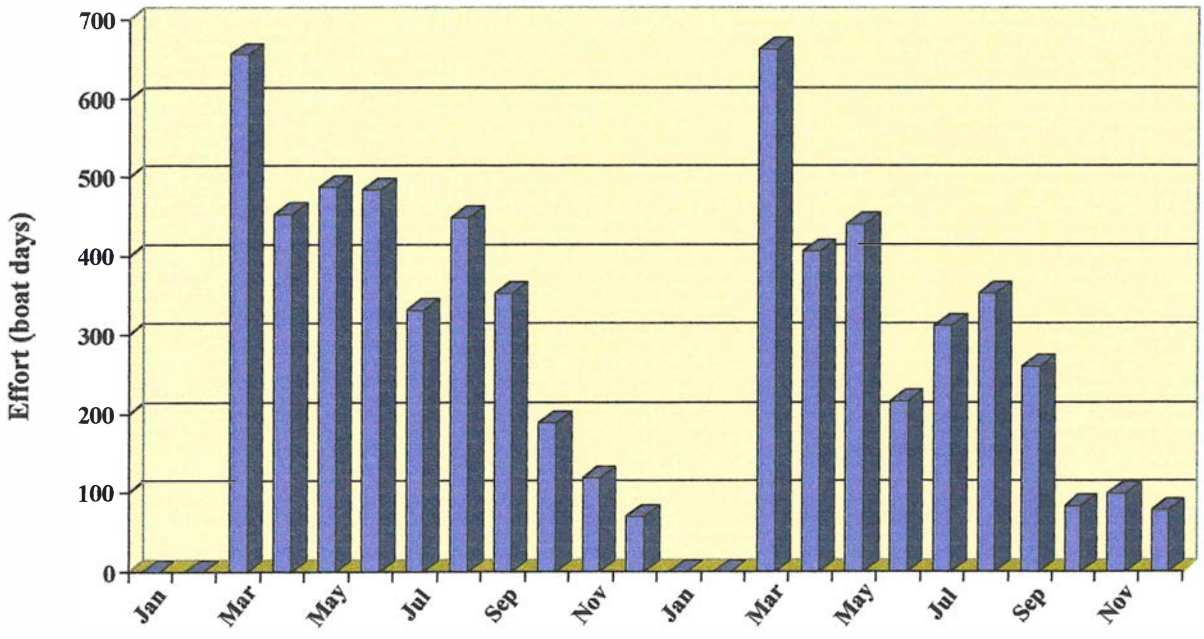

Figure 14. Monthly fishing effort in the Turtle Group region, 1993-1994.

Fishing effort in the Turtle Group region was greatest in the grid that includes Cape Flattery (Figure 15). Note that fishing effort was not necessarily evenly distributed through the 30' x 30' logbook grids. For example, we observed that the bulk of the effort in the grid that encompasses the Turtle Group (Figure 15) was concentrated close to Cape Flattery.

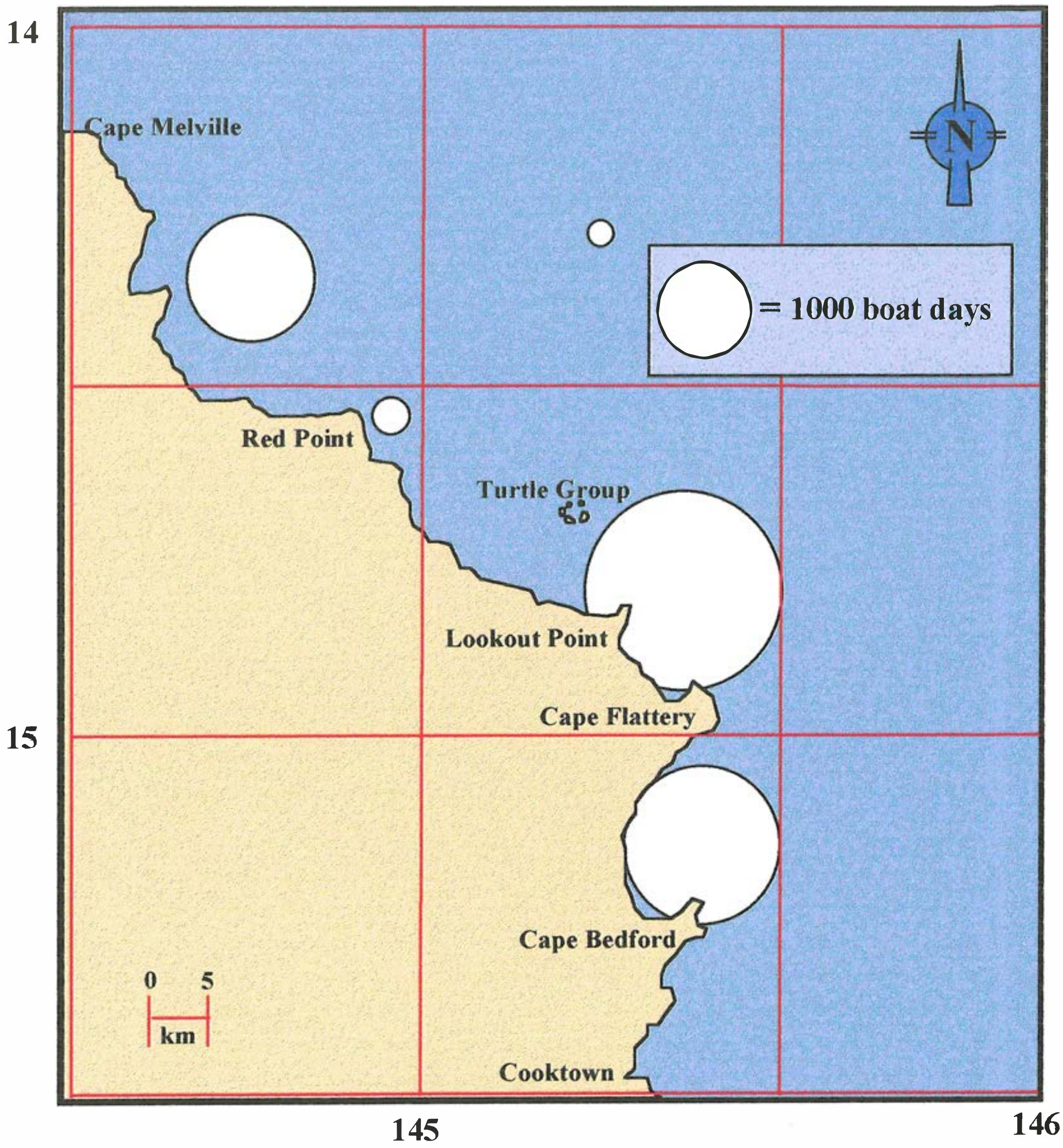

Figure 15. Fishing effort in Turtle Group region, 1993/94.

Catch in the fishery

Total prawn catch in the Turtle Group region was 769 tonnes in 1993 and 541 tonnes in 1994. The distribution of catch through the Turtle Group region reflected the effort pattern, with the largest catch taken from the logbook grid that encompassed Cape Flattery (Figure 16). Endeavour prawns made up the largest proportion of the catch in this grid (Figure 16). In the less heavily fished grids to the north and south, however, the more valuable tiger prawns made up a larger proportion of the catch (Figure 16). Fishers generally do not identify their catch to species level in the ECTF. Endeavour prawns in our samples consisted of approximately 96% blue endeavour and 4% red endeavour prawns. Tiger prawns comprised 61% brown tiger and 29% grooved tiger prawns, and king prawns consisted of about 89% red spot king prawns and 11% western king prawns. Users of GFS (see *Geographical Fisheries System: Visualising fisheries data*) can readily examine commercial prawn species composition in the Turtle Group region.

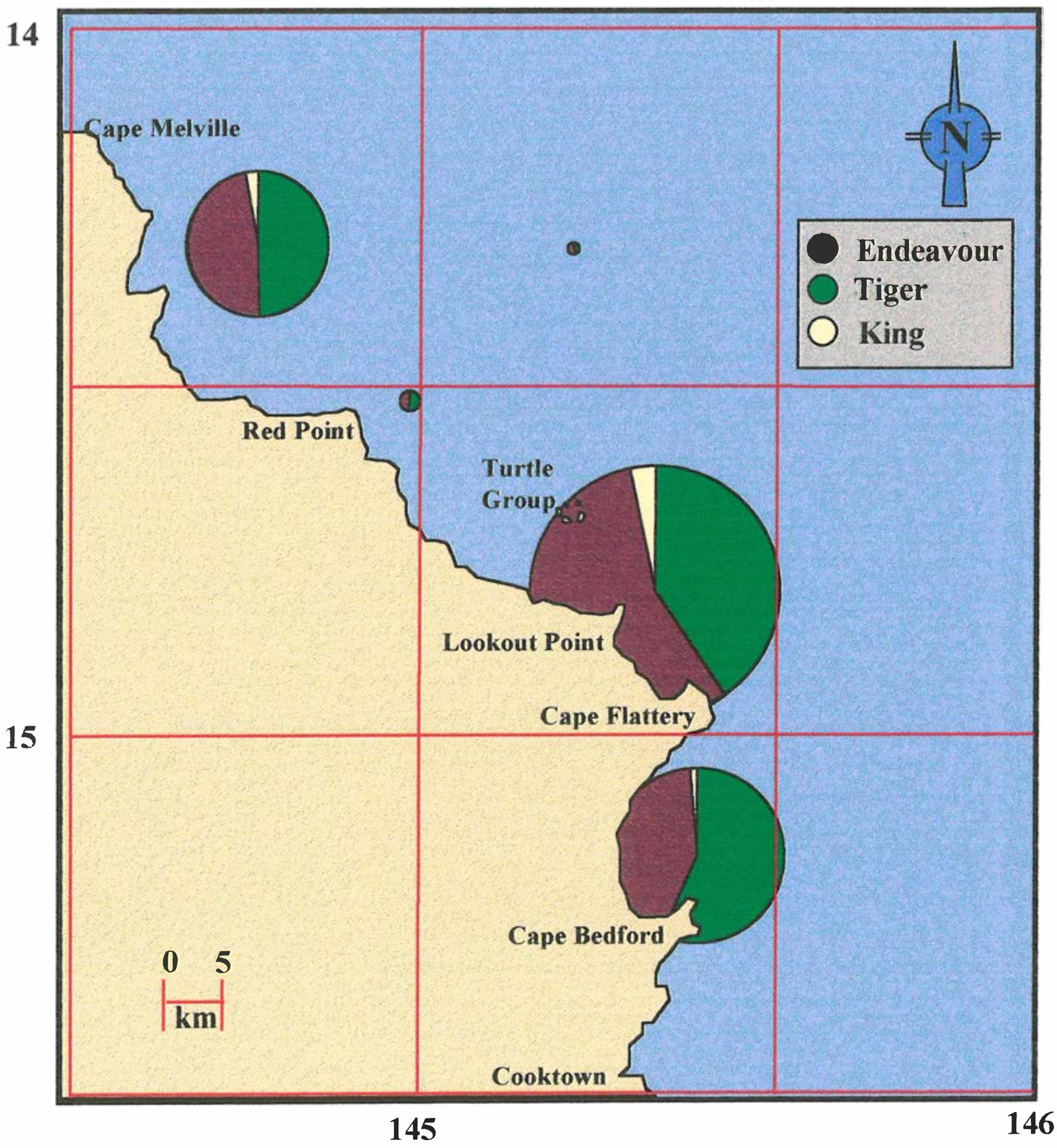

Figure 16. Catch in Turtle group region, 1993/94.

The strip closure: Minor impacts

The strip closure had little impact on the catch value of the fishery in the Turtle Group Region in 1993 and 1994. Simulations of strip closures predicted only minor changes in catch value compared to no closure (Figure 17). The largest change was an increase in catch value of 2% for a closure set at 5 m, and while benefits were generally less for deeper closures, the differences were small (Figure 17). Minor adjustments to the current closure, then, are likely to have only small effects on catch value. Users of GFS (see *Geographical Fisheries System: Visualising fisheries data*) can move the current closure lines and view differences in prawn size and species composition between closure options. It is important to note that the changes predicted here are for the fishery as a whole and individual fishers may not necessarily be effected equally.

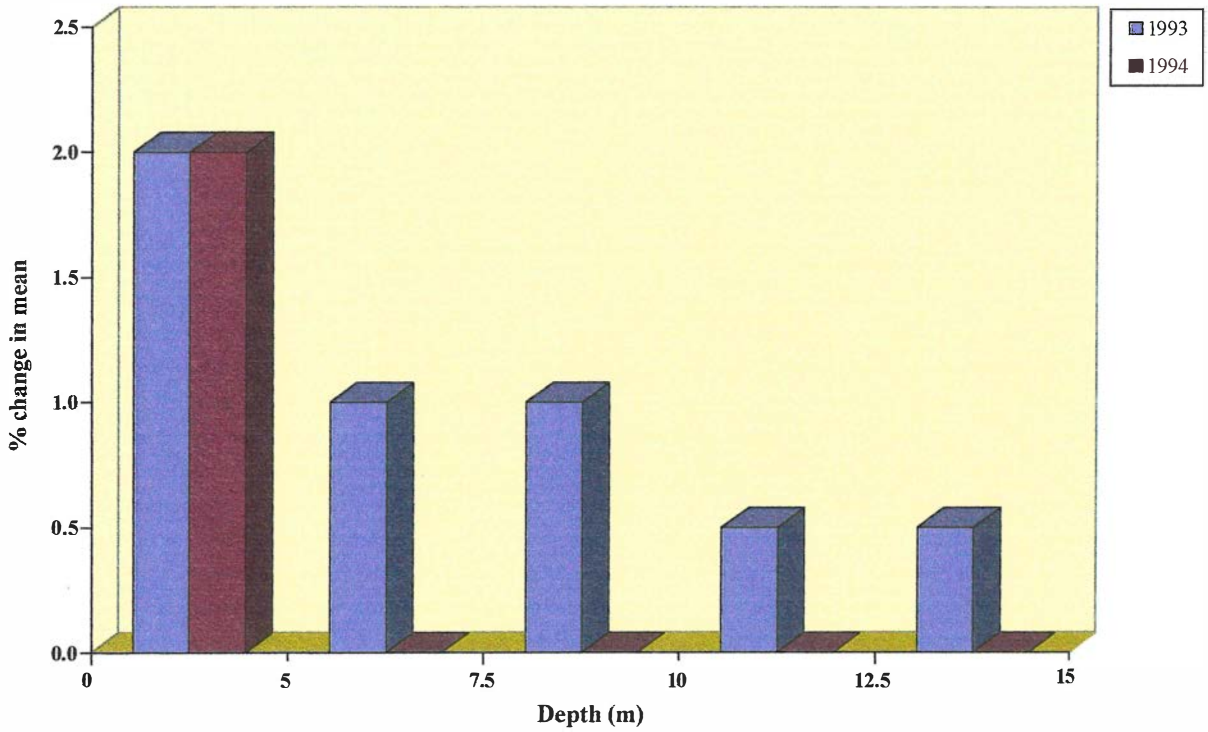

Figure 17. Predicted change in catch value for strip closure options in the Turtle Group region.

Simulations predicted only small changes for both years, even though there was considerable variation in recruitment timing between years (see *Recruitment of commercial prawns*). This suggests that the strip closure may be a relatively stable management tool in a sometimes highly variable environment.

The broad size range of prawns in closed waters undoubtedly contributed to the minor impact of the strip closure. While the strip closure did prevent the capture of many small prawns, there were also many export-size prawns inside the closure. We encourage readers to use GFS (see *Geographical Fisheries System: Visualising fisheries data*) to examine the size distribution of prawns in the Turtle Group region.

Why the strip closure should be kept

The Turtle Group strip closure provided only minor benefit to the fishery in terms of catch value. It does, however, protect the region's coastal seagrass beds from damage by trawling. These shallow water seagrass beds are crucial to the long term viability of the fishery due to their role as nursery habitat (see *Juvenile prawns and nursery habitat*). Removing the closure or moving it into very shallow water could threaten the long term viability of the fishery in the Turtle Group region. Until more detailed studies of the distribution of juvenile commercial prawns on shallow water seagrass beds are carried out (see *Juvenile prawns and nursery habitat*), we recommend protection of seagrass from trawling to a depth of approximately 10 m in the Turtle Group region. The current Turtle Group strip closure (Figure 12) is set reasonably close to the 10 m depth contour and should adequately protect coastal seagrass beds from trawling.

Changes to the strip closure

Any changes to the current strip closure should focus on protecting waters up to approximately 10 m deep. Part of the strip closure in the region between Lookout Point and the Turtle Group (Figure 12) includes waters deeper than 10 m. Our simulations predicted lesser benefits for closures set in deeper waters. Closures lines currently set deeper than 10 m could be moved closer to the 10 m depth contour and still adequately protect commercial prawn nursery areas, while slightly increasing the benefit of the closure in terms of catch value. Note, however, that our simulations predicted the maximum difference in catch value between a "deep" and a "shallow" closure was only 2% (Figure 17).

The closure is set at about 5 m depth between Lookout Point and Cape Flattery (Figure 12), which allows access to a relatively sheltered area in which to trawl during bad weather. It is probably not necessary to increase the depth of this part of the closure to 10 m, as Coles *et al.* (1985) only found seagrass in very shallow water in this area.

It is worth noting that this discussion of the strip closure focuses on the role of seagrasses as commercial prawn nursery habitat. Seagrasses also serve other important functions (see *Why deep water seagrasses are important*) which managers may be required to take into account in future.

Geographical Fisheries System: Visualising fisheries data

Objective ❹ | *Develop an interactive, animated model that can be used as an educational and decision-support tool for managers and industry.*

Summary

GFS (Geographical Fisheries System) is an interactive, animated tool for visualising fisheries data. It is designed to assist in fisheries management decision-making by providing users with a better understanding of the fishery. GFS includes the following features:

- The facility to track the movement of objects (eg tagged prawns) through time on a map.
- Thematic mapping functions such as displays of prawn densities at different sites through time.
- The facility to move closure lines and view differences between closure options.
- The PrawnEd educational module.
- Although GFS was developed specifically for the Turtle Group region, it is flexible enough for much wider application.

Recommendations

- Further development of GFS should be dependent upon feedback from users.
- If there is sufficient demand from users, PrawnEd should be expanded to include additional species and fishery information.

Introduction

Computer models have been developed in recent years to help managers understand how fisheries behave. Many of these are simulation models which "predict" what might happen in a fishery given various scenarios. AbaSim, developed by the South Australian Department of Fisheries, simulates what might happen in a reef fishery for abalone. Users of AbaSim "play games" to learn about the dynamics of the fishery. The game-playing simulation approach has also been used in models developed by Hilborn and Walters (1991) and the Food and Agriculture Organisation of the United Nations. We used a simulation model, Simsys (see *Simsys: A tool for closure asessment*), to assess the Turtle Group strip closure.

An alternative approach to simulation is to display data in a manner that those interested in fisheries management will find instructive. We opted for this "data display" approach, including animation and interactivity. GFS is not a predictive model, rather, it is a tool for visualising fisheries data in a geographical fashion. We encourage readers to use GFS to gain further insight into the prawn fishery in the Turtle Group region.

Methods

Consultation

Potential users were consulted to determine the system requirements of the model. Those consulted with included:

- Fishers
- Managers from the QFMA
- Scientists from DPIQ, CSIRO Fisheries, NTDPI&F and VFRI.

Model programming

GFS was programmed using C and C^{++}, and uses Visual Basic custom controls. The educational module PrawnEd was programmed using Visual Basic and is also available in *html* format.

Model assessment

During its development, GFS was trialed by fisheries students from Southern Cross University. We also trialed the software on a variety of IBM PC platforms with a range of data.

Results & discussion

System requirements determination

Consultation with potential users provided us with a daunting array of directions in which the model might be developed. Some of those consulted asserted that the software should focus entirely on the Turtle Group region, whereas others felt that a more generic package was essential. Some felt that the software should be educational, whereas others thought an assessment tool would be most useful. Some were of the opinion that the package should be restricted to strip closures, while others wanted as many variables as possible incorporated. Such variables included debt levels, latent effort, prices, exploitation rates, technological/efficiency advances, and maximum sustainable yield.

Given the time frame in which we operated and the objectives of the study, we were unable to incorporate many of the features nominated as important by those consulted with. We opted to include features which would:

- educate and assist with decision-making
- provide users with interactivity and animation
- make best use of available fisheries data for the Turtle Group region
- provide flexibility for wider application

Documentation

A Users Manual is provided with GFS. Extensive system documentation including the complete source code of GFS is available for future development. Documentation is also provided in the form of comprehensive on-line help.

Basic users

Data analyses for the Turtle Group region are preset for basic users. These analyses display research data collected during the Small Prawn Habitat and Recruitment Study and are intended to provide users with information relevant to fisheries management options in the region. Users can interact with animated analyses by clicking on objects (eg a tagged prawn or a sampling site) to display more detailed information about that object. There is also the facility to move closure lines and view differences in prawn size and species composition between closure options. Because of its focus on the Turtle Group region, this version of GFS is known as the "Turtle Group Release". GFS includes the following animated, interactive sample analyses based on data collected in the Turtle Group region during this study:

- Tiger prawn movement (tagging)
- Commercial prawn densities and species composition
- Juvenile prawn densities and species composition
- Commercial prawn size composition

Data is displayed in GFS on appropriate maps. The following maps are also provided as part of GFS:

- A basic map of the Australian mainland featuring a detailed section of coastline and coastal waters in the Turtle Group region.
- A basic world map.

Advanced users

GFS is a flexible package which allows users to visualise appropriate data in any geographical location. Advanced users can:

- import data from a range of sources for thematic or tagging analyses
- import maps from *MapInfo*
- Input data for tagging analyses
- Draw new maps or make modifications to existing maps

These advanced features give GFS application beyond the Turtle Group region.

PrawnEd

PrawnEd is a stand-alone educational module included with GFS. It is an intuitive, "point and click" application intended to provide a general audience with basic information about prawns and the fishery in the Turtle Group region. It contains the following features:

- General information about commercial prawn species in the Turtle Group region
- Meteorological information from the Turtle Group region
- Prawn distributions in Australian waters
- Prawn size information for the Turtle Group region
- Prawn life history information
- Catch and effort information from the fishery in the Turtle Group region

Instructions and help on using PrawnEd are provided in the GFS Users Manual.

A Web version of PrawnEd is available on the Internet at *http://ensis.nth.dpi.qld.gov.au* or *http://131.242.111.20.*

Transfer of results to clients

The project leader attended Cairns branch QCFO meetings on two occasions and updated members on project progress. The project leader discussed the study on ABC regional radio and on Cairns community radio in 1993, and presented a seminar on the study at the 1993 Pre-season Prawn Workshop in Cairns.

We produced four newsletters which were distributed to fishers during the study. A final newsletter summarising our findings will be distributed shortly. Fishers were also sent letters with information about the growth and movement of tagged prawns that they returned.

PrawnEd and excerpts from this report are available on the Internet at *http://ensis.nth.dpi.qld.gov.au:80/* or *http://131.242.111.20:80/*.

Publications arising from this study

Watson, R.A., Turnbull, C.T. and Derbyshire, K.J. (in press). **Identifying tropical penaeid recruitment patterns.** Proceedings of the "Workshop on Spawning Stock-recruitment Relationships (SRRs) in Australian Crustacean Fisheries." Bribie Island, Queensland, June 1994.

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Acknowledgments

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