Development of a spatial Decision Support System (DSS) for the Spencer Gulf penaeid prawn fishery, South Australia

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Received 11 October 2004; received in revised form 13 June 2005; accepted 14 July 2005
Available online 17 November 2005

Abstract

The Spencer Gulf penaeid prawn fishery in South Australia has undergone a substantial increase in fishing efficiency (and profitability) mainly due to the implementation of adaptive harvest strategies requiring rapid response for change to harvesting plans. This paper describes the management background and the decision-making process leading to the development of a basic Decision Support System (DSS) that uses spatial information techniques and near real-time fishery-independent survey data. The system is implemented through linking an Oracle database to ArcGIS, Genstat and Splus. Two examples show the application of the DSS for optimal harvest timing and assessment of fishery sustainability. Fishery-independent survey data are used to assess stock and model population growth. The first example shows the information flow leading to a dynamic stock model and the estimate of value change as a function of harvest time. The second example shows how the DSS is used to validate and refine existing biological reference limits by evaluating long-term detailed data sets of the prawn population structure and catch dynamics. We conclude that it is important for the economic benefit and sustainability of the fishery to maintain and improve the collection of long-term data sets that are independent of commercial fishery statistics.

Keywords: DSS; Reference points; Real-time management; Adaptive harvest strategies; Harvest model; Sustainability; Biological reference points; Profitability; Oracle; GIS

Software availability

DSS data: Partly classified government property and cannot be distributed. A standard export file of the Oracle database constituting the core of the DSS can be requested from the corresponding author without charge
Name: PRS
Developers: Rowan Hoskins, Neil Carrick
First available: 2005
Minimum hardware requirements: 1 GHz, 256 MB RAM
Software requirements: Operating system Win 2000, NT, XP
Language: English

1. Introduction

There are three prawn fisheries in South Australia — Spencer Gulf, Gulf St Vincent and West Coast — all of which are based exclusively on the western king prawn Melicertus latissulcatus (Peneidae).

The Spencer Gulf fishery (Fig. 1) is the largest Australian producer of western king prawns and is one of five Australian commercial trawl fisheries that produce more than 1500 t per annum. Descriptions of the fishery, prawn fishery biology and management are documented (Carrick, 1982, 1996, 2003; Carrick and Ostendorf, 2005).

It has long been recognized by research and members of the Spencer Gulf prawn fishing industry that fishery sustainability can only be maintained if fishing effort is constrained and directed in space and time, with an adaptive and real-time management approach. Adaptive harvest policy changes are
expected to improve yield and economic performance compared to simpler regulatory systems that do not take advantage of information about changes in distribution and abundance and spatio-temporal changes in prawn size composition. Such limitations on harvest strategies (e.g. closures and controls of trawl effort) are often difficult to define and the interests of individuals in the fishing industry may influence management decisions with a potential impact on the fishery. Discussions about how to limit the spatial and temporal extent of fishery trawl closures and the amount of trawl effort (and catch) will always occur within the fishing industry. This is where objective decision support is needed the most (Walters and Ludwig, 1987; Hilborn and Walters, 1992) yet few integrated intelligent systems based on fishery-independent survey and commercial catch and effort data have been developed in fisheries for the evaluation and prediction of stock and for the determination of allowable catch levels (Riolo, in press; Sazonova et al., 1999; Walters and Collie, 1989).

The objectives of this paper are to describe the Spencer Gulf prawn industry, the need for management, and the constraints to the design of a DSS due to government regulations. We show how a basic DSS is used to address these issues and recommend that impediments hindering innovation and further development of database systems and the DSS be removed through industry having a larger role in the research and management process. We show two examples of how the DSS is used to increase fishery profitability and fishery sustainability.

1.1. Management of the fishery

Industry has an important role in the fishery decision-making process through a Fishery Management Committee (FMC) consisting of members of industry and government. Real-time adaptive management is undertaken by a sub-committee of the FMC, the “Committee at Sea” and government (Primary Industries and Resources South Australia, PIRSA). Government management policy has instilled strict guidelines for research and management, including requirements for mandatory completion by fishers of fishery catch and effort logbooks, fishery-independent trawl surveys for stock assessment and fine-tuning of harvest strategies.

The priority in the management of the prawn fisheries is to ensure that the fishery is sustainable so that future generations may benefit from the exploitation of the resource. Primary management objectives for the Spencer Gulf fishery are as follows:

- To maintain the biomass within historical levels and eliminate the risk of recruitment decline due to overfishing;
- To ensure harvesting procedures are directed towards optimising size at capture;
- To maintain and enhance the profitability of the fishery by optimising prawn size, market timing, minimising the costs of fishing and the administrative costs of managing the fishery; and
- To minimise bycatch and trawl impact to the benthos through the development of more effective and efficient gear and harvesting strategies.
Caddy and McMahon (1995) and others have provided a detailed background into the conceptual and applied aspects of reference points for fisheries management. Reference points allow a decision framework to be developed, however, reference points and performance indicators need to be updated and refined regularly. This is particularly important as reference points are to a large degree based on anecdotal knowledge as long-term consistent and detailed data are not available, however, a continuous stream of current and future fishery data will allow these reference points to be substantiated.

Reference points provide a quantitative measure of a performance indicator that is used as a benchmark of performance against objectives, and can be used to trigger a management response. They are agreed and quantitative measures used to assess the performance of the fishery based on defined management objectives. Government, in collaboration with industry developed the biological reference points for the Spencer Gulf fishery. The reference points that drive the requirements for information collection are as follows:

- Maintain exploitation rates at present levels of effort. The target reference point for effective effort is between 70 and 80 fishing nights, while the limit reference point is 80 effective effort nights. Effective effort is a function of the amount of trawl effort (hours, days) and the fishing power (or catching efficiency) of the fleet.
- Maintain at least 50% of the virgin spawning biomass. This target indicator is the level of the recruit of the year spawning biomass, which remains after fishing and is assessed in November–December. The limit reference point for protecting the resource is that exploitation should not reduce the stock to a level of less than 40%.
- Maintain the recruitment index at a level that ensures suitable recruitment to the fishery. The reference point is based on the assessment of recruits to grounds in the February period of each year. The target reference point developed by management (Morgan, 1996) is the number of prawns (male and female) <35 mm carapace length (mm CL) in a standardised hour of trawling. Based on Morgan’s review (1996) the target reference point will maintain an index of 40 and the limit reference point was set at 35 prawns/h trawled.
- Establish a size that ensures the optimum utilisation of the resource. This target considers the size of prawns landed and the price per kg. The Management Plan states that the size of prawns taken during fishing operations is monitored nightly to ensure that effort is being targeted to prawns which provide the best return based upon market demand, whilst meeting the sustainability objectives. The target reference point for prawn size is <40 prawns/kg and the limit is 40 prawns/kg.

The economic and biological reference points are the subject of continuing research, which is undertaken in collaboration between government and the FMC. Closures are the main management tool. Throughout a fishing period, areas available to fishing can change as fishing progresses. Therefore, fishing areas are opened and closed based on the size of prawns, catch rates, depletion, spawning status and likely migration patterns of prawns.

The types of closures in Spencer Gulf consist of the following:
- Permanent area closures — to protect small prawns and vulnerable discards.
- Seasonal area closures — variable and used to protect small prawns, prevent reproductive depletion, and optimise the value of catch for different levels of recruitment and stock size.
- Total Gulf seasonal closures — December–March and June–November, to reduce trawl effort and to protect spawners.
- Total Gulf moon closures — to reduce fishing inefficiency and maintain quality of catch.
- Daylight closures — to reduce fishing inefficiency and further reduce the impact of trawling on discards and habitat.

A key feature of this fishery is the use of real-time monitoring and the corresponding changes to fishing strategies throughout the fishing periods in response to the daily movement of prawns and fleet depletion rates. Effective communication of real-time information is critical to ensure that management is conducted in a sustainable way. The skippers of vessels have a major role in reporting real-time information during fishing operations, with the Committee at Sea assisting in the development of harvest strategies by providing real-time data on the size composition of prawns and spatial catch rates.

2. Need and design strategies of the prawn DSS

The fishery is managed in collaboration between government (PIRSA) and industry to ensure fishing operations are sustainable and profitable. The Coordinator at Sea has an important role in coordinating discussion with operators and communicating information to a shore-base maintained by a fishery scientist who develops harvest strategies in collaboration with the Committee at Sea and the FMC. The decisions of the FMC are based on trawl survey data, daily information on prawn size and catches from industry and modelling to determine the optimum utilisation of the resource.

Two types of trawl surveys are conducted — large-scale stock assessments (February, April and November) of predetermined locations, and strategic (or “spot”) surveys required for the refinement of harvest strategies during fishing operations. The large-scale surveys (16–24 boat days) and the spot surveys (usually one night involving two to five vessels) are conducted by multiple vessels with similar gear and vessel physical characteristics. Strategic surveys are undertaken immediately prior to fishing or during fishing operations. Through an agreement with industry, the Gulf is totally closed to commercial fishing operations during the trawl surveys. Industry pays for the costs associated with the conduct of the surveys (e.g. boat hire, equipment, observers etc.) and
provides funding for the shore-base computing and communication system.

Data from surveys are collected at two levels of detail. The first level includes basic information ("bucket count") on spatial catch rates or biomass density (kg/h), prawn size as (no. of prawns/7.0 kg bucket), average size (g), size grade (no. of prawns/kg) of pooled sexes, as well as water temperature and depth. Survey results are communicated to industry in tabular form with maps of spatial catch rates and prawn size.

The second level includes sample size frequencies, catch, effort and current market prices for different prawn grades to analyse, biomass (kg/h) and prawn size, and harvest simulations in order to provide background information for discussions at FMC meetings and increase the speed of development and communication of harvesting strategies.

The key objectives of the DSS are as follows:

- To allow rapid information processing,
- To develop a link of spatial and non-spatial data with statistical analysis software, visualisation and communication tools,
- To allow a fast analysis of fishery data and assess spatial and temporal patterns in catch size composition and depletion,
- To improve fishery monitoring and stock assessment by efficient information communication, GIS mapping and analytical techniques,
- To allow a comparison with historical harvesting strategies.

The DSS needs to facilitate the rapid evaluation of real-time survey data through spatial visualisation and a statistical comparison with historical data. With visual analysis and statistical evaluation, management decisions are more objective because they are based on the vast amount of knowledge and information from historic harvesting efficiencies and research projects. A further objective of the DSS is a long-term influence on the collection of data by suggesting changes to the data collection process and the update of reference points.

The DSS needs to be flexible and adaptable but in turn, the necessary sacrifice was the lack of a comfortable user interface. The prawn DSS will be used by a limited number of people in a few committees (Committee at Sea and the FMC). Therefore, the operation of the DSS can rely on highly trained and experienced operators with statistical modelling and GIS skills as well as basic SQL knowledge. This means that the system does not need to be a fully integrated, fail-safe menu-driven software package with limited functionality. Hence, we opted for a modular approach that uses commercial software packages rather than developing a single new package for the DSS. In particular, GIS and statistical software packages are frequently being enhanced and the modular structure of the DSS improves adaptability to new developments in the software market. Less effort was spent on user friendliness than on flexibility and we emphasised efficiency and comprehensiveness during the development of the DSS.

Efficiency was maximised by using the most advanced database technology (Oracle), a commercial GIS (ArcGIS) and statistical software packages. Comprehensiveness was ensured by incorporating government and industry databases and placing much effort on entering historical data, applying rigid quality control at the level of data entry into the database. The Oracle database constitutes the core through which all data flows are controlled (Fig. 2).
Technically, the linkages between the software components of the DSS were kept as simple as possible. The exchange between different software components is realised through ODBC (Open Database Connectivity) drivers of the Windows operating system or simply through text files. The database runs on a laptop and is therefore transportable. The DSS configuration, forms and SQL procedures are detailed in Carrick and Ostendorf (2005).

3. Application of the DSS for adaptive real-time management

The economic sustainability of the fisheries depends on a careful exploitation of the region. The fishery regulatory system has to deal with both growth and recruitment overfishing risks. Growth overfishing, whereby small prawns are captured before optimal gains in growth and biomass can take place, is a common problem in fisheries and potentially results in economic waste. Recruitment overfishing results in a lack of sustainability of a fishery.

The first example addresses growth overfishing. We show a decision framework for predicting optimal timing of harvests to ensure that profits remain high whilst minimising the impact of trawling on trawl discards and habitat through reduced trawl effort (Fig. 3).

The second example addresses the sustainability of the fishery. Of particular importance for penaeid fisheries management is the knowledge of the spawner–recruit relationship. Recruitment is defined as the incorporation of new individuals to the population as a consequence of success in reproduction. Harvesting targets the larger size classes but, clearly, sustainability depends on spawners and a continuous stream of recruits. Research has shown that penaeid stocks are susceptible to recruitment overfishing (Penn et al., 1995; Wang and Die, 1996; Gracia, 1996; Ye, 2000, among others). A nonlinear relationship between the abundance of spawners and the numbers of recruits in the following year was demonstrated in the Spencer Gulf fishery (Carrick, 1996). Hence, the amount of catch taken prior to spawning needs to be limited to reduce the likelihood of recruitment overfishing, and quantification of temporal spawning patterns is required by management to develop sustainable harvest strategies.

3.1. Optimisation of catch value (prevention of growth overfishing)

Annual trends in prawn catch and nominal effort from 1978/1979 to 2000/2001 (Fig. 3) show that high production has been sustained. The 1986/1987 decline is discussed in more detail in the second example below. The reduction in effort from 46,000 to 19,800 h was accompanied by a substantial increase in the size composition of catch. The landings of smaller prawn sizes declined from 43 to 4% and the larger size classes increased from 29 to 76% (Carrick, 2003). Larger prawn size grades fetch at least double the value of smaller grades. Production has increased despite a halving of nominal trawl effort, which resulted in at least a doubling of real fishery profitability (value of catch minus costs of fishing) between 1978/1979 and 1998/1999.
Trawl surveys conducted before commercial fishing begins provide vital information on the size composition and the spatial distribution of the stock. Once data are obtained from surveys, simulations are carried out to determine the optimum period to fish different areas in order to optimise economic return. The DSS provides the means to quickly update the data sources for predictive models of prawn population dynamics.

The input parameters for the simulations include trawl site, catch (kg), trawl duration, trawl distance (nautical mile), size frequency samples (male and female), growth and allometry parameters, catchability, natural mortality fixed at $-0.07$ per month and current price data for different size prawns. The harvest simulation is based on a seasonal growth model of Carrick and Correll (1989) and relates the change of prawn length to the time difference between recapture and release (as a fraction of year) $\Delta t$ and the initial length ($l_0$) of the prawns at the time of release as

$$\Delta l = \beta_0 + \beta_1 \Delta t + \beta_2 \Delta (\sin(\theta - \phi)) + \beta_3 l_0 \Delta t$$

where $\theta$ is the time of release as an angular measure with one cycle per year and $\phi$ is the time of the year when growth is at its maximum. Length is converted to weight using allometric equations derived for each sex.

Growth is estimated by summing over the distribution of 1 mm length size classes (Fig. 4) for each sampling site in the Gulf for detailed analyses (i.e. level 2, see above). In the example below, data from six representative survey sites in the most important fishing ground (Wallaroo; see Fig. 1) were used to demonstrate the application of the DSS for the development of harvest strategies. Size frequency data pooled over the sites show that there are size differences between males and females with two cohorts evident in the population.

The simulation analysis for Wallaroo demonstrates that significant increase in profitability can occur by not harvesting prawns in February and March, with value increment reaching peak levels in April/May (Fig. 5). The results show that, from February 2002, the mean value increment increased by $304.9 \pm 40.78$, $627.85 \pm 85.65$ and $658.1 \pm 91.36$ per nautical mile for March, April and May, respectively. The increase in value is due to a gain in biomass growth and an increase in the size of prawns.

The industry is provided with detailed information on prawn value ($$/h) and tables on prawn size composition (grades) for each station but, normally only stations of main interest to real-time management are simulated. Other data provided include text and maps on the spatial distribution of prawn catch rates (kg/h), size and trawl value and closures. Catch rates and information on prawn size based on bucket counts (no. of prawns/7 kg) are of immediate importance to industry and information can be generated within 2–3 h following the completion of the surveys. For example, catch rate and bucket count data with maps were provided to industry within 3 h of the completion of a survey conducted in April 2001 (Fig. 6a and b). But the estimation of trawl value for all sites required the entry and validation of sample size frequency data with trawl logs, resulting in longer time to tabulate and map information from all the sampled sites (Fig. 6c). For the April 2001 survey, only information from areas 1 and 2 was mapped and presented to industry within 5 h following the completion of the survey. Information was used to develop a harvest strategy where area 1 was opened to trawling 14 h after the completion of the survey and, within the region, a small sub-region was closed to trawling as prawn sizes were smaller than the size limit (250 prawns/7 kg bucket) accepted by industry. Area 2 was opened to fishing a month later (i.e. May) to allow prawns to grow to a more valuable size.

The mapping and tabulated results from surveys are communicated to an awaiting fleet following the completion of surveys. The information provides industry and management with a broad view of the spatial distribution of abundance and prawn size. Prawn size based on bucket counts is a simple guide for industry. Many regions are not fished until prawns have a minimal bucket count of 200 per bucket, with harvest simulations used to determine optimum harvest size. The
provision of real-time data and a cooperative approach allows industry to actively participate in the management and research of the fishery.

3.2. Stock sustainability and biological reference points (prevention of recruitment overfishing)

Understanding the processes which structure recruitment, including the influence of environmental variation, is of paramount importance to the management of the resource. To be sustainable, the fishery needs to avoid recruitment overfishing by limiting the amount of prawns harvested over the spawning period (November–March). This is ascertained through an assessment of annual recruit and spawner abundance, and followed by controls on catch and harvest rates if necessary. Such controls are instigated if trawl survey sampling data show that annual recruitment and spawner abundance fall below a reference point threshold level or limit value. Threshold biological reference points are common to prevent fisheries from being over-exploited (Quinn and Deriso, 1999; Mace, 1999, among others) and provide a simple means to ensure sustainability if data are limited. Understanding of the effect of different exploitation levels on spawners and the subsequent impact on recruitment and biomass requires an adaptive learning process (Carrick, 1982). This can only be accomplished if data are systematically collected and if long-term data become available for analysis. The DSS plays a key role in facilitating this process. The analysis of spawner–recruit relationships below illustrates the DSS as a research tool allowing the validation and refinement of existing rules.

The biological reference points for the Spencer Gulf prawn fishery are based on the very low recruit level (980 prawns/nm), which occurred before the substantial decline in 1986/1987 (see Fig. 3). The decline was attributable to recruitment overfishing and low levels of spawners from 1985 to 1987. Data from fishery-independent trawl surveys indicated that low recruit abundance was associated with catches exceeding 600 t over the main spawning period (November–December) prior to 1987. The reference limits were defined using the spawner–recruit relationship established by Carrick (1996). Two basic rules were developed namely (i) if mean recruitment in February fell below a mean index of 35 (square root no./nm), action was required to reduce harvest rates and catch levels, especially over the spawning period, and (ii) if the mean spawner index fell below 90 females prawns/nm (>43 mm CL) in February, harvesting should be delayed and the catch during the spawning period should not exceed 400 t based on a similar catch landed (366 t) in the October–November 1986 spawning period, which was associated with increased recruitment in 1988. The ‘35 index’ is defined as 125% of the low recruit level of 1986.

The level of recruits/nm is determined from annual fishery-independent trawl surveys conducted in the new moon phase in February. The main region for the assessment of recruit abundance in Spencer Gulf is situated in the northern part of the Gulf, where abundance is highest and more variable (Fig. 7). Catch data obtained from commercial fishing logbooks from 1985 to 2001 were used to determine whether there was a relationship between the amount of catch taken in the spawning period (October–December) and subsequent recruitment to grounds. Catch (tonnes) landed in the October–December (spawning) period in yearn was regressed on mean recruit number (no./nm) in February in yearn+2 where recruits were defined as prawns <33 and 35 mm CL for male and female prawns, respectively. The variation of catch levels over a long time period is used to obtain an understanding of the ‘optimal catch limit’ required to ensure fishery sustainability. Catch levels over

Fig. 5. Simulation of optimal harvest period based on maximising value increment ($/nautical mile) for the main trawl ground (Wallaroo) in Spencer Gulf using input data from a trawl survey conducted in February, 2002.
spawning periods were even allowed to increase to >600 t (the critical level before the 1987 decline) when stock was high (1998 and 2001).

The results indicated a negative correlation (−0.46) between landed catch in the spawning period and subsequent recruitment to grounds. However, 1999 was removed from the analysis as the harvesting strategy was different to other years, in that harvesting was delayed and took place from mid-November to December, which would bias the relationship. With the ‘outlier’ removed, the correlation between catch and recruitment was −0.71. An exponential regression of the relationship between catch of spawners and subsequent recruitment was significant (p < 0.05) and accounted for 49.2% of the variance in the data (Fig. 8). Of main significance is that high recruitment (>2000 recruits/nm) occurred most frequently when the catch of spawners was <400 t over the spawning period. The results suggest that the catch over the spawning period should not exceed roughly 450 t to maintain high recruitment levels. Furthermore, harvesting rates from November have been delayed to allow greater spawning to take place (see below).

Spawner-recruit relationships (SRR) are more difficult to quantify as detailed size estimates are required. Data from annual fishery-independent trawl surveys conducted in February
on the new moon phase from 1984 to 2002 were used. Spawn-
ers were classified as female prawns >43 mm CL, whilst re-
cruits were male and female prawns <31 and 33 mm CL, respectively. Trawl sampling was conducted using standard
double rig trawl gear of 29.26 maximum headline length.
The survey sampling plan was based on a spatial model with
unbalanced data (Carrick, 2003). The mean estimates of
spawner and recruit abundance (no./nm) data were fitted to
four models:

1. A logistic function

\[ R_t = a + c/(1 + \exp(-b(S_{t-1} - m))) \]

2. A rational function

\[ R_t = a + (b + cS_{t-1})/(1 + dS_{t-1} + eS^2_{t-1}) \]

3. Critical exponential

\[ R_t = a + (b + cS_{t-1})(r^{S_{t-1}}) \]

4. Simple exponential

\[ R_t = a + b(r^{S_{t-1}}) \]

where \( S_{t-1} \) is the spawner abundance index in year \( t - 1 \) and
\( R_t \) is recruit abundance the following year (Fig. 9). Nonlinear
curve fitting methods used a modified Newton method of max-
imising the likelihood using stable forms of parameterisation
(Ross, 1990; Ratkowsky, 1990), with regressions constrained
to fit through the origin.

The rational model accounted for 72.8% of the variance in
the data. The simple exponential accounted for 66%, whilst
the logistic and critical exponential models explained 71.4%
of the variance. The rational model is a cubic curve with an
asymmetric maximum falling to an asymptote. The asymptotes for the rational, logistic and critical exponential models were 1649, 1628 and 1662, respectively. The modelled recruitment levels for each of the three curves using the 1996 spawner threshold (90/nm) were 1489, 1474 and 1436, respectively. That is, the modelled recruit levels at the spawner threshold were 90.5, 90.3 and 86.4% of the asymptotes for the logistic, rational and critical exponential models, respectively. The models indicate that an increase of the spawner threshold from 90 to 100/nm would result in recruit increases of 5.7, 7.4 and 5.8%, respectively, for the logistic, rational and critical exponential models. The simple exponential regression explained 66% of the variance in the data but the model is considered unrealistic with an asymptote at 2706 for a spawner abundance of approx. 1000/nm.

The recruit abundance and spawner indices obtained from February surveys provide a gauge to the health of the fishery in near real time. A decline in recruitment that approaches the recruit index threshold provides a signal for management and industry to reduce harvest rates. An assessment of the spawning stock in November allows management to develop harvest strategies in real time, the principal objective being to ensure that the fishery is sustainable.

4. Conclusions

The examples have demonstrated the need and merits of a Decision Support System (DSS) for the effective management of the Spencer Gulf prawn fishery. The basic DSS developed relies on fast data flow, and on reporting and analytical tools capable of analysing complex data. The main tools used to provide information for decision making are commercial catch and effort logbooks, fishery-independent trawl survey data, and daily monitoring of stock depletion. The management controls adapted and formulated with industry include limits or constraints on (i) catch; (ii) prawn size; and (iii) fishery depletion rates (especially prior to spawning). The control of catch levels is facilitated by daily monitoring of the fleet catch and depletion rates over each fishing period within a year, through direct control by ‘effort’ constraints (days and area fished).

The DSS has provided benefits to industry through the provision of real-time and near real-time information increasing the potential for objective decision making. Management has benefited through the provision of information on the spatial distribution of stock and on depletion rates, prawn size composition, and simulation of temporal trends in trawl value ($/h) over different spatial units of the stock. The adaptive management of the fishery based on a cooperation between industry

Fig. 8. Relationship between prawn catch (tonnes) over the spawning period and prawn recruitment to grounds in Spencer Gulf, 1985–2003.

Fig. 9. Spawner—recruit relationships in the Spencer Gulf prawn fishery fitted to logistic, rational, critical exponential and simple exponential models.
and government has a long history and has proven to be effective in maintaining high economic return. Substantial economic gain to industry has occurred due to directed targeting on different spatial units of the stock to optimise financial return from operations and reduce excessive trawl effort and fishing costs (Carrick and Ostendorf, 2005). This can be attributed in part to the small and regionally isolated community of fishers whose common interest is to maintain the productivity of their assets over the long term. The DSS provides an objective argument for management action when there is a need to control harvest rates and optimise the value of catch. Hence, the DSS has contributed to a more efficient flow of data into management actions. An important aspect differentiates the prawn industry from many other fisheries in that higher premiums are paid for larger prawn grades (size). As demonstrated, economic return can be increased in spite of a reduced catch, thereby substantially contributing to the sustainability of the industry.

The DSS allows for the provision of data for research on the sustainability of the fishery. Tools have been developed for basic stock assessment, and the incorporation of different data sources has increased our understanding of the factors that influence recruitment to prawn grounds.

Harvest strategies have aimed at maintaining recruitment by controls on catch, spatial distribution of effort and seasonal fishing mortality rates when recruit indices or spawner levels approach the reference limit. Results indicate that the target reference point for the spawner index based on surveys could be increased with greater likelihood of higher (and less variable) recruitment. A good recruitment generated by a large spawning biomass and a favourable environment has an extended, positive effect on Spencer Gulf production (and fishery value) in the intermediate and longer-term as opposed to views in favour of a quick financial return.

Sustainability of the fishery demands that the risk of recruitment overfishing be minimised and hence requires understanding of the processes that structure recruitment. The spawner-recruit relationships provide an objective guide to decision making by reducing the uncertainty of limit values. Myers (2001) points out that “spawner-recruit data are much like Hobbes view of primitive man: nasty, brutish, and short. These data are nasty because they have many undesirable statistical properties (e.g. extreme skewness), and short because data have not been collected for hundreds of years.” All SRR models developed for the fishery (except for the simple exponential) show that, as spawner abundance falls below 90/nm, the rate of decline in recruits rapidly decreases. Hence, the rationale developed in 1996 for strong management action (controls on catch and harvest rates) when limit thresholds (e.g. recruit index and spawner abundance) are approached is supported. The DSS provides the means to regularly update the SRR relationships as data are collected. Environmental variation (e.g. water temperature) can have a large effect on recruitment and needs to be explicitly incorporated in the SRR models and the fishery management process.

Future advances of the DSS strongly depend on the improved efficiency and scope of data collection. For example, currently, commercial catch and effort data are recorded on hard forms by fishers and manually entered, resulting in frequent errors and inefficiencies. A number of data attributes can be automatically captured during fishing operations by individual fishers, stored on vessel computers and electronically sent to a shore-base for porting into the DSS for quality control and analysis. Initial tests clearly indicate that substantial efficiency and cost-saving gains would accrue if the whole fleet used mobile phone technologies in the electronic transfer of data from vessel to shore.

The main impediments to development of a DSS include (i) reluctance of the whole fleet to adapt to new technology (e.g. internet); (ii) concerns of many regarding the provision of trawl location data (GPS positions) in real-time to government; (iii) failure by operators to send data (in either electronic or hard copy faxed mode) to shore-base following a specified time schedule; (iv) disagreement and conflict within industry in accepting the need for “hard” management decisions to limit catch when it is required to ensure fishery sustainability and to optimise trawl value; and (v) reluctance by research service providers to accept that adaptive management is an applied research process and is required to ensure the fishery is sustainable and economically viable.

There is a potential to obtain highest quality data for stock assessment and management of the Spencer Gulf prawn resource. The management of the fishery could be improved by industry taking on a broader ownership responsibility for research and management of the fishery in collaboration with government.

Acknowledgements

The authors wish to thank the Fisheries Research and Development Cooperation (FRDC), Primary Industries and Resources South Australia (PIRSA), the Spencer Gulf & West Coast Prawn Fishermen’s Association and the University of Adelaide for funding and administrative support. Rowan Hosking (Oracle database programmer) and Laurie Pullman (Pullman Computing) provided software implementation and hardware components of the DSS through funding by the FRDC. The Spencer Gulf & West Coast Prawn Fishermen’s Association (SPG & WCPFA) and Jon Presser (PIRSA Fisheries) provided logistic and management support. Ray Correll (CSIRO), Ari Verbyla (BiometricsSA) and Carol Moore are thanked for the stimulation and assistance provided over many years. We thank two anonymous referees who provided valuable inputs into reviewing drafts of the manuscript.

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Management Committee. SARDI Aquatic Sciences, Publication No. RD03/0079-2.