Using geostatistics to analyse prawn and scallop catch

By Ute Mueller, Lyn Bloom and John Dickson (Edith Cowan University), Mervi Kangas and Errol Sporer (Department of Fisheries).

This study of Shark Bay trawl fisheries has combined the disciplines of marine science and geostatistics to generate spatial models of prawn and scallop catch and effort data. These models will assist in formulating more informed risk assessments and reducing the chance of overfishing.

Prawn and scallop fishers in Shark Bay have been collecting catch and effort data for many years. Through this process they actively collaborate with the Invertebrate Trawl Research group and managers in protecting the prawn and scallop fishery from overfishing.

This Fisheries Research and Development Corporation (FRDC) project, entitled Spatial analysis of catch and effort and survey data from the Shark Bay prawn and scallop fisheries is being conducted jointly by mathematicians from Edith Cowan University and marine scientists from the Western Australian Fisheries and Marine Research Laboratories. Its task is to analyse the catch and effort data collected by the scallop and prawn fleets in the years 2000 to 2005 and survey data for scallops collected from 1998 to 2005.

The aims of the project are to use the spatial information available through the logbook and survey data to reduce fishing on small prawns, improve the protection of spawning stock of tiger prawns and investigate methods for scallop catch prediction. The methodology used is geostatistics, which, as the name implies, has its origins in geology and mining. In brief, the method accounts for both the location as well as the abundance at a given location so that spatial models can be developed.

Data preparation

In the first phase of the project a comprehensive quality audit of the data was conducted. This was needed because the logbook data provided more than 20,000 records each year.

The aggregated catch was allocated to a central location rather than the location at the start or the end of a night's fishing. Figure 1 shows the trajectories of a boat for two nights together with the central location to where a night's catch was allocated.

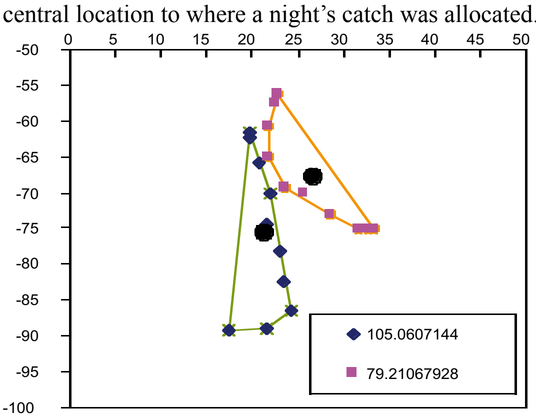

Figure 1 Typical trajectories with the hull area covered provided in the legend and centroids marked with block dots

Prawns, particularly western king prawns that provide the biggest proportion of the catches in Shark Bay, are quite sensitive to moon light. Therefore the data were grouped by the lunar week. A week-long period was considered to be enough to have sufficiently many data locations to be able to infer spatial models. The lunar weeks were calculated by centering each on a phase of the moon. The prawn fishery is closed during the full moon, so the resulting weeks were designated first quarter (Q), new moon (N) and last quarter (L).

A further aspect of the project is the analysis of the prawn catch data by size class and species. For both industry and the Department, it is very important to focus on optimising the value of the catches and in recent years the emphasis has been on targeting larger sized, more valuable prawns. The analysis of grade information allows us to see if there are any patterns in the size of prawns, particularly small prawns which can be incorporated (i.e. keep areas of small prawns closed) into annual harvesting strategies.

For this purpose the data were aggregated over a period of a lunar month (between full moon closure periods and over one square nautical mile blocks. The categories considered were grades (number per pound) used by commercial fishers: small prawns (size classes >20 per pound i.e. >44 per kg), medium-sized prawns (15-20 per pound), large prawns (<15 per pound) and 'soft and broken' prawns

Analysis of the prawn catch data

To date the analysis of the logbook data for the years 2001 to 2003 has been completed. The variables analysed are the total daily catch and daily catch rate for both tiger and king prawns, the percentage of tiger prawn catch in the total daily catch and the total daily fishing effort calculated as the total number of minutes spent fishing.

As an example, Figure 2 shows the spatial distributions for the catch rates for king and tiger prawns and the percentage of tiger prawns in the total catch for the week of the last quarter in May 2001. Catch rates for king prawns are generally higher than those for tiger prawns. For king prawns catch rates are low in the north and high in the south where the rates are above 35kg per hour. For tiger prawns there is a region of high catch rates in the north-west. This is also the only region where tiger prawns make a contribution of above 70 per cent to the total prawn catch for this week.

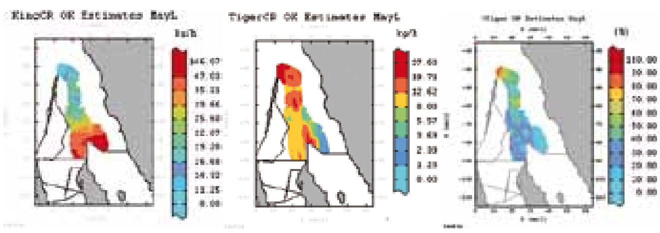

Figure 2 King and tiger prawn catch rate estimates (kg/h) and percentage tiger prawn catch, last quarter May 2001

Analysis of king prawn size class data

The amount of large, medium, small and soft/broken king prawns is shown in Figure 3. The overall amounts vary from year to year and actual levels are dependent on the recruitment in that year, the timing of the opening of the fishery and climatic influences. We note that the amount of small prawns caught in later years is less variable than in 2000 to 2003 and generally towards the end of the year (M6-8) larger prawns contribute to more of the catch in the last two years compared to 2000 to 2003 showing some evidence for improved targeting of larger prawns.

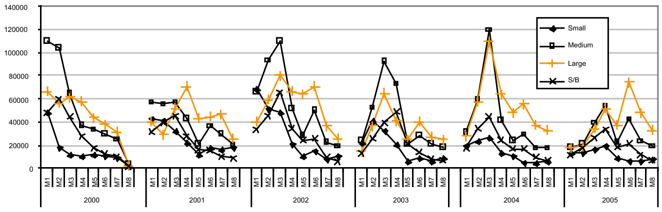

Figure 3 **Total amount of king prawns caught per size class in kg for 8 lunar months (M1 – M8) for the years 2000 to 2005.**

Investigating the catch rate distributions for small, medium and large king prawns (Figure 5) for lunar month 3 in 2004 shows higher catch rates for small and medium sized prawns in the south-east while in the north-west there are low catch rates. High catch rates for large prawns are more dispersed throughout the fishing regions. This kind of information can be used to formulate voluntary closure lines to keep out of areas of small prawns.

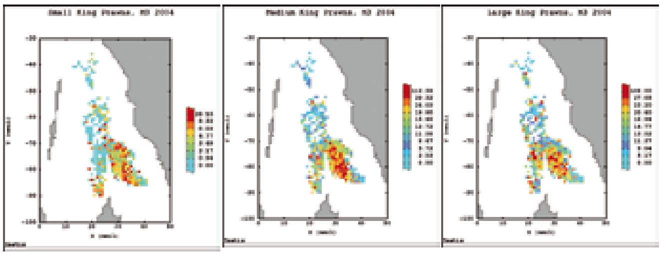

Figure 4 **Spatial maps showing the spatial distribution of catch rates of small, medium and large king prawns in month 3, 2004 (red indicates high catches and blue indicates low catches)**

Scallop survey and commercial catch data

Annual surveys of scallop stock have been undertaken each November giving information on size and abundance of scallops for analysis as well as using the commercial catch and effort data provided by skippers. The survey data is used to determine the opening time of the fishery for the following year.

The indices (numbers caught per nautical mile) are also used for catch prediction. As part of this project the survey data were used to simulate the spatial distribution of the scallops. These may then be used to identify regions of high and low scallop abundance and this information can be used to assess whether locations of high abundance in the survey corresponds to high catches in the fishery.

A typical simulated map is shown below (Figure 5) together with the input data, a map showing the expected value at each location and in this instance the total catch for the subsequent year. The simulation has locations of high and low catch and its potential for stock prediction needs to be investigated further. The ability to generate simulations that are spatially consistent with the distribution observed at point survey locations provides a means to carry out risk assessment and moreover allows the development of closure and or harvesting scenarios.

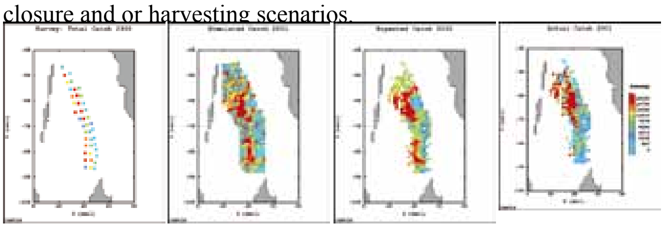

Figure 5 **Spatial maps showing the spatial distribution of scallop catch during the survey 2000, a spatial map scallop catch simulated from the 2000 survey results, the expected scallop catch calculated from the simulated catch for 2001 and the map of the actual catch in 2001 (red indicates high catches and blue indicates low catches)**

Currently the prawn catch and effort data from 2004 and 2005 are being modelled and a detailed analysis of tiger and king prawn catch by grade is being undertaken to determine if current management and harvesting strategies are improving the overall size and value of prawns caught. The next steps in the project will be looking at how prawn and scallop catches vary over time and how well scallop survey results reflect what is actually caught by fishers. The study is scheduled to conclude the end of 2008 and a comprehensive Fisheries Research Report will be published. ■

Trawler at work.