

Preliminary results from a resource study of Edible crab (*Cancer pagurus*) in Norway 2001 – 2003.

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The Norwegian fishery for *Cancer pagurus* peaked in the 1940-50's with catches of 7000 to 9000 tonnes annually. After 1955 the fishery declined, the profit remained low and by the early 90's the industry was heavily subsidized. A plan for the industry took action when subsidies were cut and the landings dropped. This, together with an increasing demand, has brought profitability into the trade again. The crab industry now wants to increase the catches by increasing the effort in traditionally area and by extending the catch area.

The lack of information about abundance and biological stock parameters became apparent during the discussion related to an increase of the present catch levels. A resource program was therefore started in 2001. Data used in this study was collected by about 20 commercial fishermen during the 2001 and 2002 fishing season. The program is still ongoing.

Each fisherman recorded from ten weeks of catches during each crab-season. Data consisted of catches from 4 special pots, and included catch per pot, carapace width, sex and quality. The data are used for spatial and temporal comparison of abundance and several biological stock parameters. Considerable differences in catch composition and quantity among the areas were found. The data will be compared with more traditionally surveys and with data from the Norwegian catch reporting system.

Keywords: *Cancer pagurus*; resource; CPUE; logbooks; annual indexes;

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1 Introduction

The edible crab *Cancer pagurus* is abundant along the Norwegian coast and the commercial fishery is at present extending from the southern part of Norway (N58°) to Vesterålen (N69°). The crab seems to spread northward, and a new developing fishery is in progress between N68°-N69°. In 2000, 2001 and 2002 approximately 75% of the landings were caught reported to Norges Råfisklag, which is the fishery sale organisation for landings from N63° and northwards. The peak season is from August to October in Trøndelag (N63° – 64.5°) where the main fishery is conducted. Farther north the fishery starts somewhat later, while in the southern part of Norway it starts in May/June. In addition to the landings in the pot fishery, there is a considerable by-catch of edible crabs in the gillnet fishery for cod and saith in late autumn and winter (ref). The landings in Southeastern Norway are not registered, being a rather small commercial or a large recreational fishery in the summer season.

The Norwegian fishery for *Cancer pagurus* peaked in 1947 – 1949 with catches of 7,000 to 9,000 tonnes annually (**Fig. 1**). After this the fishery declined gradually in the late 1980's and early 1990's. The profit remained low well into the 90's. By the early 90's the industry was heavily subsidized. A plan for renewing the industry took action when subsidies were cut and the landings dropped to less than 2000 tonnes. This together with an increasing demand has brought profitability into the trade again. The crab industry now wants to increase the catches by increasing the effort in traditionally area and by extending the catch area and the catch period.

The crab fishery is regulated by a minimum legal size of 13 cm carapace width north for N60° latitude and 11 cm carapace width south for N60°. Soft-shelled crabs and berried crabs are illegal to land. There is no estimate of the edible crab stock in Norwegian waters. The Norwegian catch reporting system gives information about the landings, but neither the effort in the fishery nor biological information. There is no compulsory logbook for the crab fishery. On account of this a 3-year resource programme was started in 2001 based on logbooks maintained by commercial fishermen (Woll *et al.* 2002; Woll *et al.* 2003).

The procedure in the logbook programme incorporates the sampling into the daily operation of the fishermen and requires a large degree of commitment and cooperation from the participating fishermen. It is directed at sampling a small fraction of the catch from randomly selected pots on a frequent basis. The sampling assumes that it is valid to combine a large number of observations from different fishermen within a geographical area to obtain unbiased estimates of the relevant parameters. Starr and Vignaux (1997) compared a logbook program and found good correlation with the data from more traditionally surveys.

The aim for the logbook program is to establish an annual recording of the catch, landing and discard in the Norwegian Edible crab pot fishery which can be conducted with a limited use of resources. The programme shall provide data for annual indexes and comparison of geographical areas according to catch-, landing- and discard data, sex ratio, size distribution and quality. The reliability of the logbook program is to be tested by comparisons with data from the Norwegian catch reporting system.

2 Methods

In the logbook program the fishermen were sourced from different statistical areas according to the Norwegian catch reporting system: area 05 (Vesterålen), 06 (Helgeland and Nord-Trøndelag), 07 (Sør-Trøndelag and Møre) and area 08 (Rogaland) (**Fig. 2**). Area 08 was added in 2002. Within each area the fishermen were subdivided according to the main wind and swell exposure in their catch area: S= sheltered; M=medium; E=exposed.

Four trial pots were distributed to all participants, and each pot was put in the middle of 4 different strings. During 10 weeks of the crab season a detail recording of all crabs caught by the 4 trial pots were conducted 4 times a week. Each reporting day (10 weeks x 4 days = 40 reporting days) the participating fishermen also reported the landing of the whole catch (in kg) and the total number of pots hauled. Landed crabs in kg/pot haul ($LPUE_{all\ traps}$) were calculated by dividing the total landing with the total number of pots hauled.

For the crabs caught in the trial pots, carapace width (CW) and sex were recorded and each crab determined to landing or discard. The landing in kg/trial pot haul (LPUE) was estimated by the weight for each crab using a CW – W (weight) relationship: $W_{females} = 0.0002CW^{2.9026}$ ($n = 301$; $R^2 = 0.958$) and $W_{males} = 0.00002CW^{3.4115}$ ($n = 78$; $R^2 = 0.923$) (A. Woll, unpublished data).

The fishermen separated the discard from the trial pots in: 1) crabs < minimum legal size, 2) soft-shelled crabs, 3) berried crabs and 4) crabs with other deformities as severe black spot disease or missing both claws.

The catch in number of crabs per trial pots was also calculated as: total number of crabs caught in the trial pots per / number of trial pot hauls (CPUE). Similar LPUE was calculated as number of landed crabs / number of trial pot hauls and DPUE as the number of discarded crabs / number of trial pot hauls.

Minimum legal size (MLS) in area 08 is 11 cm carapace width, compared to 13 cm width in the other regions. LPUE was calculated for the crabs > 13 cm CW in order to compare with the other regions. Hence, the commercial LPUE in area 08 was somewhat higher than reported here.

ANOVA was used to test differences in: 1) LPUE and $LPUE_{all\ traps}$. Comparison were done both between and within different areas. Bonferroni statistics indicated which groups differed from each other. Difference in size distribution (CW) was tested by the use of Kolmogorov-Smirnov statistics.

3 Results

3.1 Mean LPUE and $LPUE_{all\ traps}$

In 2001 the 19 participating fishermen recorded 20,614 crabs from 2,730 trial pot hauls. In 2002 all together 29,831 crabs were recorded of 25 fishermen from 3,369 trial pot hauls (**Table 1**).

Total landings reported on the recording days were 362,506 kg from 135,785 pots in 2001 and 427,643 kg from 152,808 pots in 2002.

Mean LPUE and $LPUE_{all\ pots}$ were compared between the catch areas 05, 06, 07 and 08 in 2001 and 2002 (**Table 1**). Only small differences between LPUE and $LPUE_{all\ pots}$ were found recorded. However, there was no trend in these differences and the trial pots seemed to catch as good as the average pot used by the fishermen. In the future only LPUE data is used to indicate catch rates.

When LPUE for 2001 and 2002 were compared between the catch areas (**Table 2**) LPUE for area 06 was significant higher than LPUE for all the others. Further more LPUE for area 05 and 08 were the smallest and no significant difference was found between these.

Within all areas the data was split into exposed, medium and sheltered regions. For area 06 and 07 LPUE in the sheltered region was lower than in exposed and medium. The opposite was found for area 08 (**Table 2**) although data from this area is somewhat limited.

3.2 Sex ratio and size distribution

Sex ratio and mean carapace width were calculated for the catches >MLS in different areas and exposed, medium and sheltered regions within these (**Fig. 3**). For all areas females were less abundant in the catches from the exposed areas and highest for the sheltered regions, respectively 60.5% and 84.7% in average in average numbers respectively. For catches from the medium regions the abundance of females were something in between, except for area 08 where no difference were found for exposed and medium regions.

Mean carapace width were highest (females: 16.4 cm, SD=1.3; males: 17.5 cm, SD=1.8) in the sheltered regions of area 07 and lowest (females: 13.9 cm, SD=0.9; males: 14.2, SD=1.1) in exposed region of area 08 (**Fig. 4**).

3.3 Variation in LPUE during the season

The crab fishery starts earlier in the southern part of Norway then farther north. Due to this the logbook recording in 2001 commenced in week 31 for area 07, in week 34 for area 06 and in week 40 for area 05. The bulk of the data in 2001 was collected from week 36 to week 42 (**Fig. 5**).

In 2002 the logbook recording started in week 31 for area 08 and 07. At this time the crab fishery in area 08 had kept on for 1-2 months, while the fishery in area 07 started at this time. In area 06 and area 05 the logbook recording and the commercial fishery started simultaneously, in week 34 for area 06 and in week 40 for area 05. Most of the data in 2002 were collected from week 34 to 42 (**Fig. 5**).

The fishing depth varied during the recording period. In the beginning it ranged from 15 to 30 m, then increasing in week 36/37 to 40 – 50 m in area 06 and 07 and to 80 – 100 m in area 05. In the southern part, area 08, the fishing depth of some reason decreased to 13 - 20 m at this time.

The catch data was stratified by week and catch area and the results were compared for 2001 and 2002. For area 06 and 07 LPUE seemed to be higher in 2002 than in 2001 and highest in the beginning of the season with catch rates about 6-7 kg/pot haul in average. After 2 - 3 week fishery the catch rates decreased to about 2 – 3 kg/pot haul (**Fig. 6**). When comparing LPUE for the fishermen, most of them had higher LPUE in 2002 than in 2001.

The amount of soft shelled crabs in the catches bigger than MLS was analysed (**Fig. 7**). It seemed as the soft-shelled crabs were earlier observed in the catches in 2002 than in 2001, which indicates that the moulting was earlier this year. In area 05 the amount of soft-shelled crabs was higher in 2002 than in 2001 and in the end of the fishing period about 60% of the catches (in number) were soft shelled. In area 06 there also seemed to be more soft-shelled crabs in 2002 while in area 07 it was approximately the same. In area 08 recording is only for 2002 and soft-shelled crabs were present through the whole recording period increasing rapidly and at the time the fishery ended, week 40, soft-shelled crabs constituted 70% of the catches. At this time soft-shelled crab were abundant just in a small scale in the other regions.

3.4 Discards

The total amount of landing and discard (in number) for 2001 and 2002 was found for the different areas and regions within these (**Fig. 8**). The amount of crabs < MLS was considerable higher in region 08 and highest for the exposed region where 64% of the crabs were < MLS. In the exposed region of area 07 and 05 the amount of soft-shelled crabs were high, 31% and 28% respectively.

In the group “other discards” crabs with black spot disease, berried crabs and crabs with deformities were counted. These crabs constituted only a small fraction of the catch varying from 1-4% of the total number of crabs in the pots (**Fig. 8**).

4 Discussion

The design of the logbook programme is meant to represent and indicate the variations in catch rates and composition throughout the season within the different areas, with the use of limited resources.

The Norwegian coast is stretching out from temperate to arctic climate zones, and it is expected that geographic variations and resource exploitations can be considerable from south to north. In area 05 no crab fishery has previous been carried out, and the fishery was more like a trial fishery where different locations and depths were investigated. The fishery started in October both years, which seemed to be too late to get the best outcome of the fishery.

Compared to the other regions very few records were carried out both in 2001 and 2002. In area 06 no commercial fishery was done for several years during the 1990's, and the region is not heavily exploited at the moment. The landings per boat and crab quality are very good. Area 07 has been heavily fished for many years and the crab from this region has a good reputation for being of good quality, larger and more abundant than elsewhere. The fishery in region 08 differs somewhat from the other regions, as they deliver to other customers, both industrial companies and live to the public. The open sale to the public is most important during summer, and is probably a reason for the small MLS and the long fishing season, compared to further north.

Analyses of size frequency, sex-ratio, soft-shelled crabs, berried crabs and crabs with missing claws are conducted. These analyses will be used for further comparison both within and between areas of the edible crab fishery. Such information will be important for evaluation of the management of the crab fishery in the future, as the interest for extended seasons, extended fishing areas and improvements in fishing gear is increasing.

A description and evaluating of existing catch and effort data sets for the edible crab stock in England and Ireland are undertaken by Tully *et al.* (1999) who also discuss limitation of existing data collection and possible way of improvements. The result from the logbook program will be compared with the data presented and evaluated by Tully *et al.* (1999).

The design of the logbook programme requires that the sampled pots are representative of each participant's activity. LPUE is expected to be similar to the overall $LPUE_{all\ traps}$ for each fisherman. As well, the LPUE of the participating fishermen could be compared with that of all crab fishermen. The results so far are promising. The program is going on this season (2003). However, it is desirable with a continuation of the programme for further 2 years. An evaluation of the method will be undertaken in order to assess the suitability of such data for monitoring and assessment of crab stock.

5 References

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Tables

Table 1. Catch area, number of fishermen, number of trial pot hauled and landed crabs in kg per trial pot haul (LPUE) and all pot hauls (LPUE_{all pots}), standard deviation in brackets. Results from the Norwegian logbook program in 2001 and 2002.

	No. of fishermen		No. of trial pot haul		LPUE		LPUE _{all pots}	
	2001	2002	2001	2003	2001	2002	2001	2002
Area 05	1	3	41	239	1.4 (0.6)	1.3 (0.6)	1.2 (0.4)	1.6 (0.6)
Area 06	8	9	1 315	1 264	3.4 (1.3)	3.7 (1.7)	3.4 (1.3)	3.4 (1.4)
Area 07	10	9	1 374	1 309	2.6 (1.1)	3.1 (1.2)	2.6 (0.9)	3.2 (1.4)
Area 08	-	4	-	557	-	1.5 (0.8)	-	1.7 (0.6)
Total	25	0	3 369	0	2.94 (1.30)	2.94 (1.57)	2.95 (1.30)	2.94 (1.42)

Table 2. Landed crabs in kg/trial pot haul (LPUE) in the logbook program in average for 2001 and 2002. Catch area split in exposed (E), medium (M) and sheltered (S) regions, standard deviation in brackets.

	LPUE (kg/trial pot haul)			
	Total	E	M	S
Area 05	1.3 (0.6)	1.2 (0.5) ^a	1.6 (0.8) ^b	-
Area 06	3.5 (1.5)	4.1 (1.6) ^a	3.3 (1.4) ^b	2.9 (1.2) ^c
Area 07	2.8 (1.2)	2.8 (1.2) ^a	3.0 (1.1) ^a	1.9 (0.9) ^b
Area 08	1.5 (0.8)	1.3 (0.5) ^b	1.3 (0.8) ^b	1.9 (0.8) ^a

Unequal letters (^{a,b,c}) within an area marks significant differences

Figure captions

- Fig. 1** Recorded landings in the Norwegian fisheries of crab (*Cancer pagurus*) from 1914 to 2002.
- Fig. 2** Map showing statistical areas for catch landings in Norway. Red circles represent logbook reporting fishermen in the pot fishery for Edible crab (*Cancer pagurus*) in 2002: area 05 (Vesterålen), 06 (Helgeland), 07 (Trøndelag and Møre) and area 08 (Rogaland).
- Fig. 3** Sex ratio for crabs > MLS in the catch from the trial pots in 2001 and 2002. E=exposed area; M=medium and S=sheltered area. MLS=13 cm carapace width.
- Fig. 4** Mean carapace width for females and males >MLS in the logbook program 2001 and 2002.
- Fig. 5** Number of trial pot hauls in different catch areas from week 31 to week 48 in 2001 and 2002.
- Fig. 6** Landed crabs in kg/trial pot haul (LPUE) in the logbook programme 2001 and 2002 (SD as vertical bars).
- Fig. 7** Percent soft crabs >MLS (in number)/trial pot haul in the logbook programme 2001 and 2002. MLS=13 cm carapace width.
- Fig. 8** Number of landed and discarded crabs/trial pot haul for the logbook program in 2001 and 2002. E=exposed area; M=medium and S=sheltered area. MLS=13 cm carapace width.

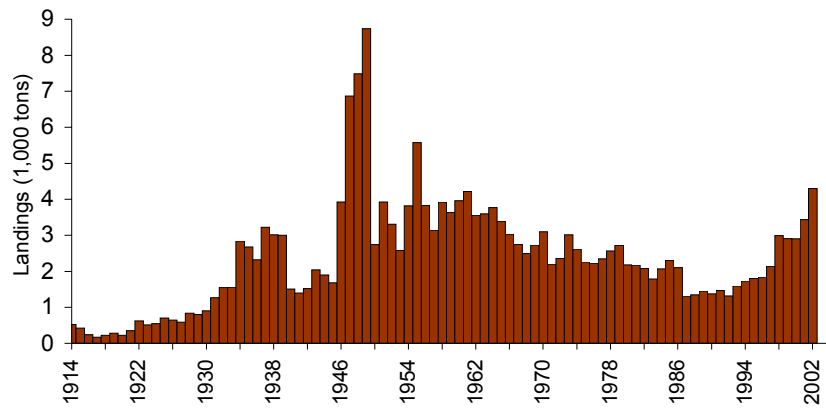


Fig. 1

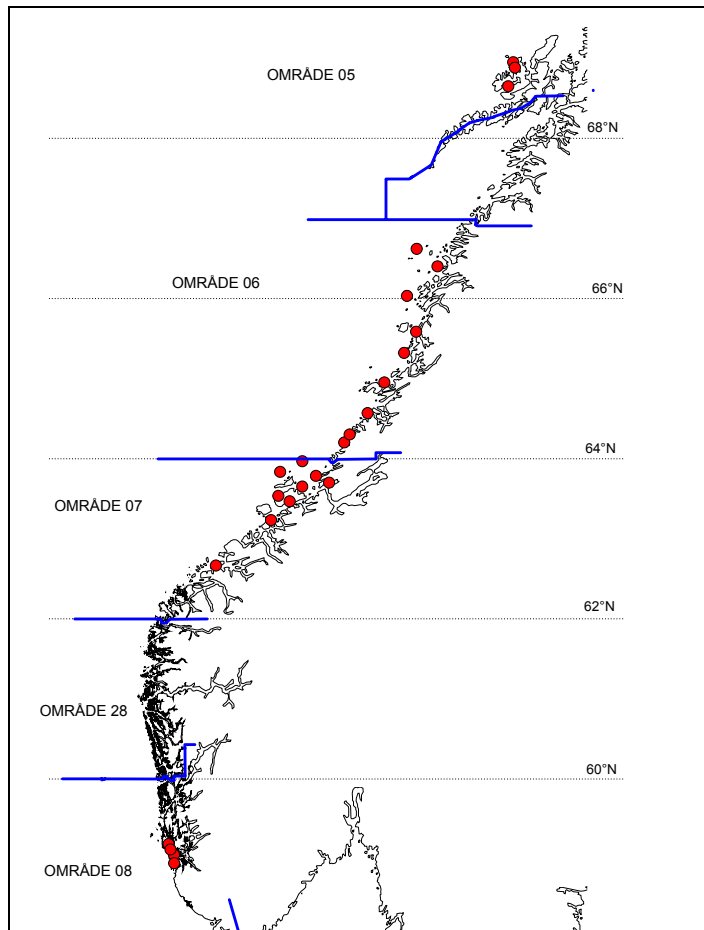


Fig. 2

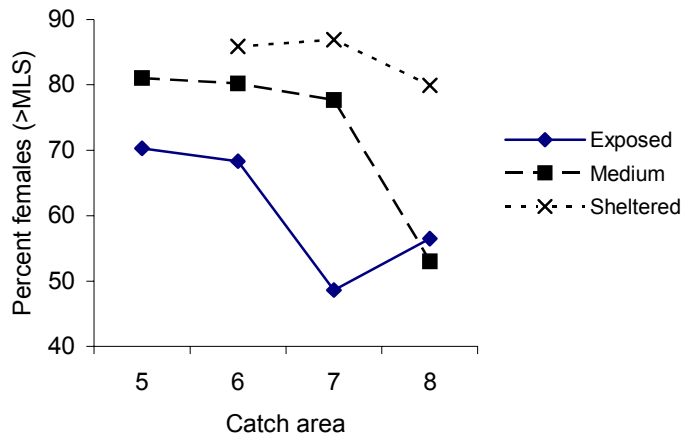


Fig. 3

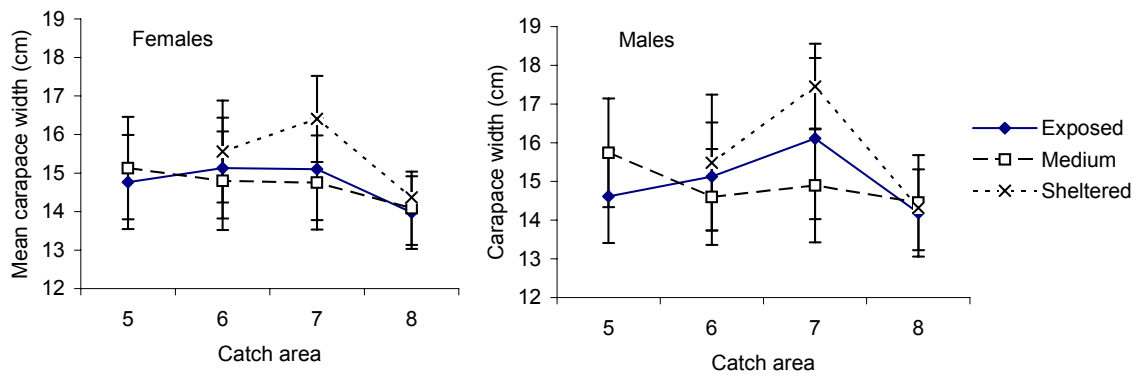


Fig. 4

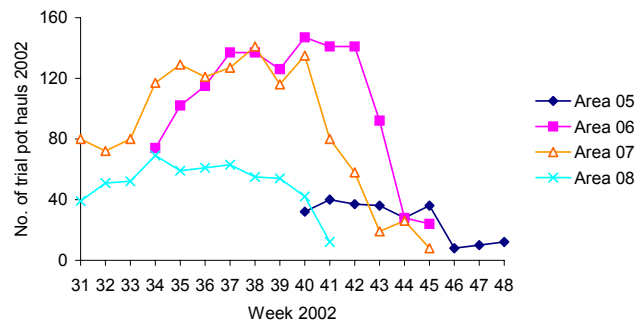
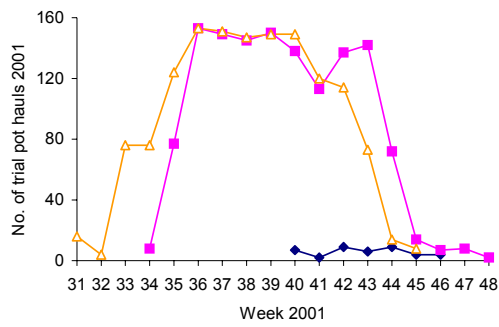


Fig. 5

a

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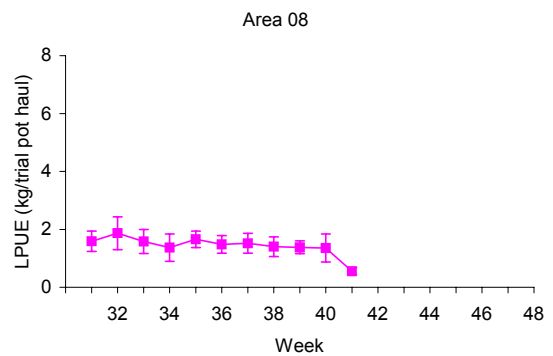
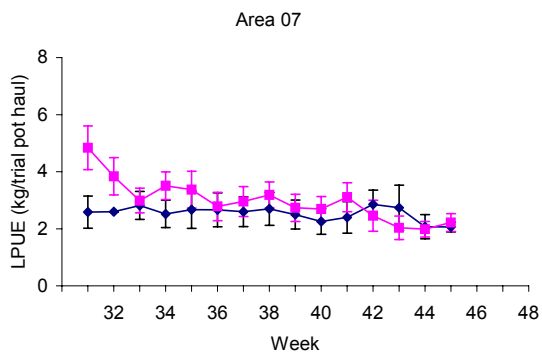
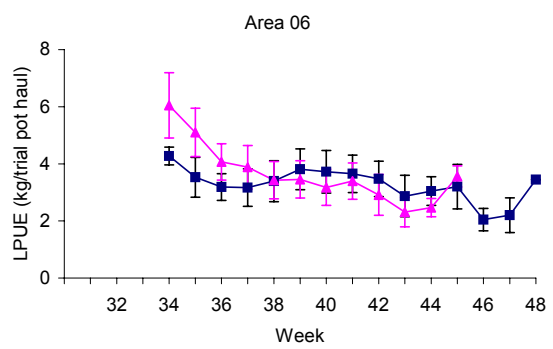
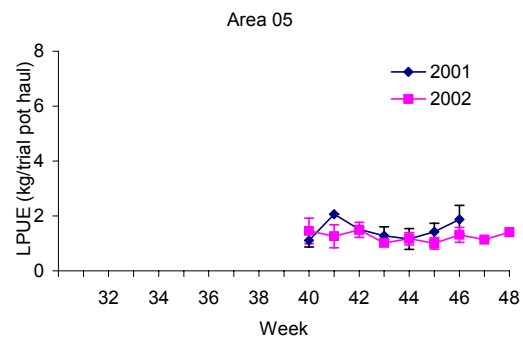


Fig. 6

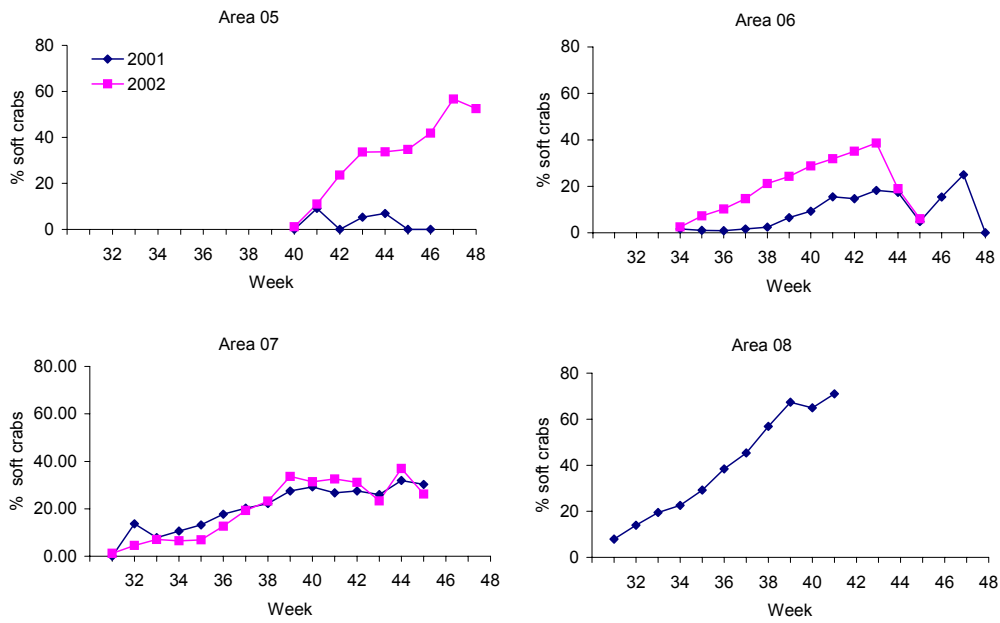


Fig. 7

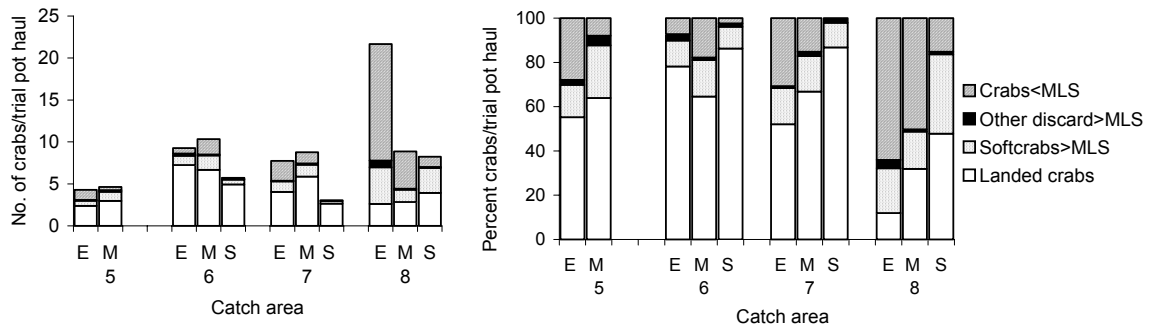


Fig. 8