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A Re-examination Of The Methods Used For Handling Undersize Western Rock Lobsters

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CONTENTS

TABLES | PAGE

FIGURES

A RE-EXAMINATION OF THE METHODS USED FOR HANDLING UNDERSIZE WESTERN ROCK LOBSTERS

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I INTRODUCTION

The fishery for the western rock lobster, Panulirus cygnus (George) is the most important single species fishery in Australia, and one of the major rock lobster fisheries of the world, with catches over the last ten years (1973 to 1983) averaging approximately 9.8 million kg annually.

The continuing success of the fishery can be attributed mainly to effective management, which involves a complex system of regulations, the majority of which were introduced in 1963 and which are constantly being revised to accommodate changes in the fishery. One important piece of legislation, effective from 17 December 1965, was the introduction of a two inch (51 mm) escape gap in all rock lobster pots. The purpose of the escape gap was to allow the majority of undersize western rock lobsters [1] (less than 76 mm carapace length) to escape before the pot was brought to the surface. The escape gap was increased to 54 mm on 15 November 1972. In exchange for using a larger escape gap the regulation prohibiting fishing within one mile of the shore after 1 January each season was abolished.

However, despite the presence of the escape gaps, large numbers of undersize are caught still, especially from the 0-10 fm depth

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1. Hereafter undersize western rock lobsters are often referred to as undersize.

range. It has been estimated that some 16 to 20 million undersize have been brought aboard the 765 professional rock lobster boats each season, and of those retained, 24% remained on board for ten minutes or more, with some being kept out of water in excess of two hours (Brown and Caputi 1983).

Even though the undersize are returned to the sea as required by the regulations, it has been shown that not all of them survive (Brown and Caputi 1983, Brown et al. in press). The reason is that damage suffered by many of them from conflict in the pot and from handling on board the boat (exposure, damage and displacement) may prove fatal. The effects of capture and handling also render them vulnerable to predation during the fall back to the sea floor, owing to disorientation caused by the experience.

Brown and Caputi (1983 and 1985) and Brown et al. (in press) examined the retention and release experience (handling) to ascertain the effects of damage, exposure and displacement, separately and in combination, on survival of undersize. They then estimated the economic consequences of the mortality of undersize directly or indirectly caused by those effects. It was found that all of these factors, damage, exposure and displacement, resulted in an estimated reduction in recapture rate of 14.6% in the 1978-79 fishing season. After taking into account natural mortality, the total loss to the rock lobster industry due to poor handling methods was $9.1 million (Brown et al in press). Brown et al. (in press) examined the way fishermen emptied rock lobsters from the two different types of pot used in the fishery:

a. Beehive or stick pots were emptied ("skinned") by hand. The fishermen pulled lobsters out through the neck of the pot by holding onto the antennae, carapace or tail. The rare exception to this method were fishermen who had swing-out doors built into the steel bases of their pots.

b. Batten or slat pots were usually emptied by opening the door (gate) at the end of the pot, tipping the pot up and emptying the lobsters out through the open end, into a 'cacca box'. Some batten pots were emptied by hand through the neck like beehive pots.

An important feature of emptying pots by hand, whatever the pot type, was that the obviously undersize rock lobsters were thrown straight back into the water. It was sometimes observed also that when a pot was emptied directly into a 'cacca box', as with batten pots, the sorting fishermen threw back the obviously undersize first.

Brown et al (in press) identified seven different handling methods used to sort rock lobsters:

1. Sorting direct from the pot (sequence 1) - Rock lobsters were taken by hand, from the pot and gauged (measured) to determine whether they were size or undersize. Undersize were immediately returned to the sea and the size rock lobsters were kept. The most important difference between this and the other five sorting methods is that it does not involve the use of a 'cacca box' to store the captured animals until they are gauged.

2. Sorting after each pot (sequence 2) - Rock lobsters were transferred from the pot into a 'cacca box' and then sorted directly from the 'cacca box'. All the animals from one pot were sorted before the next pot was pulled (and hence more lobsters were added to the box).

3. Continuous sorting (sequence 3) - Rock lobsters were sorted from the 'cacca box' whenever there was time available, usually while pots were rebaited and stacked, when steaming between pots and when winching the next pot aboard.

4. Erratic Sorting (sequence 4) - Sorting occurred when the 'cacca box' was full, or when a need to determine the catch rate arose. The contents of the 'cacca box' were completely sorted after a line of pots (i.e. a number of pots in a particular location) had been pulled, even if the 'cacca box' was not full.

5. End of line sorting (sequence 5) - Rock lobsters were sorted from the 'cacca box' after pulling a line of pots (Brown _et al_. in press). In some cases the obviously undersize were sorted directly from the pot.

6. Sorting after pulling and relaying a line of pots (sequence 6) - Pots were emptied into the 'cacca box' and sorting took place only after a line of pots had been pulled, rebaited and reset. This procedure usually involved moving the line of pots some distance before resetting them.

The results showed that if fishermen modified their sorting methods, the effect of these factors could be greatly reduced, and hence the mortality of undersize associated with these factors would also be greatly reduced.

Using the results of the study, the Fisheries Department initiated an intensive 18 month education programme to inform fishermen of the magnitude of the problem and the urgent need for them to change their handling methods to significantly reduce this serious source of wastage created by industry.

The objective of the study reported here was to determine what types of sorting methods are being used now by fishermen, and what proportion of the fishing fleet is using each of them. These results can then be compared with those of the initial study by Brown et al. (in press) for the years 1977 to 1980, to evaluate the success of the education programme and to assess the need for any further action that may be required to remedy the problem.

As in Brown et al. (in press), several characteristics of the fishery facilitated reliable observation of a significant proportion of the rock lobster fishing fleet, i.e. the practice of daily fishing trips and the congregation of the commercial fleet in 12-15 major anchorages minimized the time and effort required to locate and monitor vessels. In addition, the relationship between industry and research personnel was good and it was very difficult for fishermen to change ingrained handling practices for an observer's benefit.

II METHODS

The rock lobster fishing fleet was monitored during the 1983-84 rock lobster season. A sample was taken of one hundred and fifteen boats (15% of the fleet) at seventeen anchorages along the coast (Figure 1 and Table 1). Fishermen working gear in depths of 36 m (20 fms) or less, were approached to take research staff on board. The depth constraint was adopted because the greatest numbers of undersize rock lobsters are caught within this depth category (Brown and Caputi 1983).

On board the fishing boats, the time when each rock lobster pot was brought aboard (i.e. start time) and the pot type was recorded, and an estimate of the number of rock lobsters in the pot was made. The rock lobsters were taken from the pot and either thrown overboard if undersize or carrying spawn, or placed in the sorting box ('cacca box') from which they were then either returned to the sea (undersize and spawners) or kept with the catch (i.e. lobsters with a carapace measurement greater than or equal to 76 mm). During the sorting process, the numbers of undersize, size and spawning animals were counted and a total for the three groups was made when sorting was completed. When all the undersize had been returned to the sea, an end time was recorded. When the next pot was pulled, timing started again. If all the rock lobsters were not sorted before the next pot was pulled, a partial sort notation was entered and the time recorded. Timing started again when the next pot came on board.

Of the six sorting sequences observed in the initial study by Brown et al. (in press) and described in the Introduction, only sequences 1 to 5 were observed during this study.

There were two major pot types used by the boats sampled (see Table 2) beehive pots (pot type 1) and batten pots (pot type 2). A small number of steel pots were also used (pot type 3) and some fishermen at different locations used various combinations of the above. The results (Table 2) may be compared with the same information derived from research log books (i.e. a random sample of the fleet) (Table 3).

While aboard the fishing boat, notes on the weather, depths fished, 'cacca box' construction and its position on the boat, baits used, crew composition, general handling of rock lobsters, evidence of predation and other features of the fishing operation were obtained.

At the end of the fishing trip, research staff assigned a sorting sequence to each boat, based on what was observed during the collection of the data.

Data Processing

The data were collated and processed using a programme written by N. Hall (Fisheries Department, P.O. Box 20, North Beach, 6020, Western Australia). The programme calculated expected exposure times for each of the five sorting sequences using the following three methods, each of which is based on a different assumption:

METHOD 1. Assumes rock lobsters from each pot are sorted randomly from the 'cacca box' and an estimate of exposure time is obtained for each individual.

METHOD 2. Assumes the last pot of animals added to a 'cacca box' would be the first sorted and provides an estimate of the mean exposure time for animals sorted from the layers of lobsters built up from each added pot: i.e. an average exposure time for each pot full of animals is calculated.

METHOD 3. Assumes the last pot of animals added to the 'cacca box' is the first to be sorted, as in Method 2, but exposure times are estimated for each animal individually rather than on average exposure time for each pot.

The distribution of exposure times (in five minute intervals) was calculated over all boats monitored and over boats using the same sorting method.

Each boat monitored was equally weighted with regard to catch rate by using percentages of undersize handled rather than the actual number counted, the percentage being weighted in proportion to each boat's pot licence. This prevents possible bias occurring through the selective use of certain handling methods by boats of a particular size.

Method 2 was used as the basis for the results presented in this paper, because it was observed to be the most representative model of how sorting actually occurred on board the boats. From observations, when rock lobsters were put into a 'cacca box' little mixing occurred between those lower down and those just put in. Layers of rock lobsters from successive pots tended to form in the 'cacca box'. The only exceptions occurred when catch rates were low or a wet tank was used as a 'cacca box', in which case many newly introduced rock lobsters tried to get to the bottom or corners of the tank, by forcing themselves below other rock lobsters.

III RESULTS

Methods of sorting rock lobsters from the pot

The locations at which the five sorting methods observed in this study were used are given in Table 4, and associated pot types are given in Table 5. The percentages of sampled boats using the five sorting methods were as follows:

1. 7.8% sorted direct from the pot (sequence 1).

2. 40.0% sorted after each pot (sequence 2).

3. 42.6% sorted continuously (sequence 3).

4. 4.4% sorted at the end of a line of pots (sequence 4).

5. 5.2% sorted at the end of a line of pots (sequence 5).

90.4% of the sampled boats used sorting sequences 1,2 or 3. Figure 2. shows the percentage of boats sampled using each of the above sequences, compared to the previous study.

Percentages of undersize sorted using each method:

1. Boats sorting direct from each pot handled 7.8% of the undersize (Fig. 3).

2. Boats sorting after each pot handled 40.4% of the undersize (Fig. 3).

3. Boats sorting continuously handled 43.5% of the undersize (Fig. 3).

4. Boats using erratic sorting handled 4.5% of the undersize (Fig. 3).

5. Boats using sorting at the end of a line, handled 3.9% of the undersize (Fig. 3).

91.7% of the undersize were sorted using methods 1,2 and 3. Figure 3. shows the percentage of undersize sorted using each method compared to the previous study.

<u>Exposure times of undersize for each of the sorting methods</u>

For the entire sample (all boats section, Table 6A and Fig. 4) 87.5% of the undersize were sorted within 0-5 minutes, 5.0% were sorted within 5-10 minutes (cumulative 92.5%), 3.5% were sorted within 10-15 minutes (cumulative 96.0%), 2.0% were sorted within 15-20 minutes (cumulative 98.0%) and the remaining 2.0% were sorted within 20-80 minutes.

Exposure times obtained for each of the sorting methods were:

1. Sorting direct from the pot (Table 6A) - 99.0% of undersize handled using this method were sorted within 0-5 minutes, 0.5% within 5-10 minutes, and the remaining 0.5% within 10-20 minutes.

2. Sorting after each pot (Table 6A) - 97.0% of the undersize handled using this method were sorted within 0-5 minutes, 1.0% within 5-10 minutes, 0.5% within 10-15 minutes, 0.5% within 15-20 minutes and the remaining 1.0% within 20-40 minutes.

3. Sorting continuously (Table 6A) - 85.5% of the undersize handled using this method, were sorted within 0-5 minutes, 7.0% were sorted within 5-10 minutes, 3.5% within 10-15 minutes, 1.5% within 15-20 minutes, 1.0% within 20-25 minutes, 1.5% within 25-40 minutes and the remaining >0.5% were sorted after 40 minutes.

4. Erratic sorting (Table 6A) - 52.0% of the undersize handled using this method, were sorted within 0-5 minutes, 14.5% within 5-10 minutes, 17.0% within 10-15 minutes, 10.5% within 15-20 minutes, 3.5% within 20-40 minutes and the remaining 3.0% were sorted after 40 minutes.

5. Sorting at the end of a line (Table 6A) - 47.0% of the undersize handled using this method, were sorted within 0-5 minutes, 23.0% within 5-10 minutes, 15.5% within 10-15 minutes, 9.5% within 15-20 minutes, 4.5% within 20-25 minutes and the remaining 0.5% were sorted within 25-35 minutes.

The longest exposure times were observed on boats using erratic sorting (sequence 4).

COMPARISON WITH INITIAL STUDY (1977-80)

Percentages of sample observed using each of the sorting methods

In the initial study (Table 6B), the percentage of monitored boats using each of the six sorting methods was:

1. 5.6% sorted direct from the pot (sequence 1).

2. 15.2% sorted after each pot (sequence 2).

3. 27.2% sorted continuously (sequence 3).

4. 4.8% sorted erratically (sequence 4).

5. 37.6% sorted at the end of a line of pots (sequence 5).

6. 9.6% sorted after relaying a line of pots (sequence 6).

When compared with the sample from the current study, it can be seen (Figure 2) that there have been marked decreases in the percentage of fishermen sorting at the end of a line of gear (sequence 5) and sorting after relaying a line of gear (sequence 6) i.e. from 37.6% to 5.2% and from 9.6% to 0% respectively. There have also been large increases in the percentages of fishermen sorting after each pot (sequence 2) and sorting continuously (sequence 3) i.e. from 15.2% to 40.0% and from 27.2% to 42.6% respectively. There has been virtually no change in the percentage of fishermen in the erratic sorting category.

In the initial study, only 20.8% of boats monitored were observed to use sorting sequences 1 and 2, whereas in this study, 47.8% of the boats monitored were observed using sequences 1 and 2.

Percentages of undersize sorted by each of the sorting methods

In the initial study (Table 6B), the percentages of the total undersize caught by the fishermen for each of the sorting methods were as follows:

1. Boats sorting direct from each pot handled - 6.4%.

2. Boats sorting after each pot handled - 13.0%.

3. Boats sorting continuously handled - 26.2%.

4. Boats using erratic sorting handled - 4.5%.

5. Boats sorting at the end of a line handled - 40.9%.

6. Boats sorting after relaying a line of pots handled - 9.0%.

A comparison of the results of the initial study (Table 6B) with the results of this programme (Table 6A) shows considerable changes in the percentage of undersize handled by sorting techniques 2,3,5 and 6 (Figure 3). There has been a decrease from 9.0% to 0% for undersize handled by those who sorted after relaying their gear (sequence 6) and a decrease from 40.9% to 3.9% for undersize handled by fishermen who sort at the end of a line (sequence 5). There has been an increase in the percentage of undersize handled by those sorting after each pot (sequence 2) from 13.0% to 40.4%, and by those sorting continuously (sequence 3) from 26.2% to 43.5 %. Changes in the percentage of undersize sorted direct from each pot (sequence 1) and by erratic sorting (sequence 4) were insignificant.

Exposure times

Tables 6A and 6B show the exposure times associated with each sorting method for both the current and initial studies respectively. Comparing exposure times, for the initial study (1977-80) and the current study (1983-84), for all boats and all methods combined: within 0-5 minutes, 65.0% of undersize had been sorted in the initial study, while 87.5% were sorted within the same time interval for the current study. From the initial study, 83.5% of the undersize had been sorted within 0-15 minutes, whereas the current study found that 96.0% of the undersize had been sorted within 15 minutes (Tables 6A and 6B).

An exposure time of 5 minutes or more can affect the likelihood of survival of returned undersize, and an exposure period of 15 minutes or more severely affects undersize survival (Brown and Caputi, 1983; Brown et al. in press).

In both studies sorting sequences 1,2 and 3 showed similar percentages of undersize exposed for the various 5 minute categories. For the erratic sorting method, the percentage of undersize handled within 15 minutes varied between the two studies with 89.0% for the initial study compared with 83.5% for the current study. There was also a difference between the studies for the end of line sort method, where 72.5% of undersize were exposed for 0-15 minutes in the initial study, compared with 85.5% for the current study. No comparison can be made for sorting after relaying a line of gear.

Trends with Pot Type and Sorting Method

Table 2 shows the number of boats monitored at each anchorage, using each of the seven pot types/combinations. The most common pot type was the batten pot (pot type 2), which was used exclusively by approximately 73% of the boats. Approximately 1% of the boats sampled used only beehive pots (pot type 1) and no boats used exclusively steel pots (pot type 3). The remaining 26% of the sampled boats used combinations of these three pots. When these figures are compared to the pot types used by boats monitored during the initial study, it can be seen that there has been a large decrease in the percentage of boats using pot type 1 (i.e. beehive pots only) from 33% to 1%, an increase in the percentage of boats using pot type 2, from 63% to 73% and an increase in the percentage of boats utilizing combinations of pots, from 4% to 26%.

However, a comparison between the pot types recorded during the current study and the pot types indicated by fishermen filling out log books (Table 3), i.e. approximately 25% of the commercial fleet, it can be seen that there was an underestimate of the percentage of the fleet that utilizes only beehive pots. From log book returns, approximately 16% utilize only beehive pots as opposed to 1% from this study. This study observed greater numbers of boats using combinations of pots when compared with log book returns, while the percentage of fishermen using batten pots differed only slightly.

Table 5 shows the number of boats monitored with the pot types used and the sorting methods employed. It appears that sorting methods were not restricted to any particular pot type. The batten pot (pot type 2), the most common type used, was associated with the five sorting methods observed. However, most boats using batten pots used sorting sequence 2 and 3.

The only boat sampled that had just beehive pots (pot type 1) used sequence 3. In the initial study it was observed that boats using only beehive pots tended to use sorting sequence 1.

Table 4 shows the numbers of boats at each anchorage observed to be using the various sorting methods. The results show that sorting sequences 1,2 and 3 were not restricted to any particular region of the fishery. These three sorting sequences were used by 90.4% of the sample and handled 91.7% of the captured undersize.

The current study compares well with the log book results with respect to the distribution of batten pot use within the fishery. Batten pots are used from Kalbarri to Safety Bay (Tables 2 and 3). From log book data, the use of beehive pots was not restricted to any particular region of the fishery, though they appeared to be concentrated in the southern sector of the fishery. A greater variety of pot types appeared to be used in the region Cervantes to Two Rocks than in other areas of the fishery (Table 2). The greatest variety of pot types was used by boats at Two Rocks; six of the seven pot types/combinations were used, though the same diversity was not seen in the log book returns (Table 3).

General Observations

The 'cacca box', its construction, position on the boat and any special features varied widely amongst the boats. The type of 'cacca boxes' observed on boats included: metal frame with metal mesh or synthetic mesh sides and bottom; orange plastic prawn baskets; fibreglass boxes; wood-fibreglass. composite boxes; wooden boxes; aluminium boxes; plastic tubs, and box sides with the deck forming the bottom of the box. Many had rubber mats, carpet or hessian bags on the bottom. Several boats had boxes with special features. One boat was documented to have sprays in the 'cacca box'; one boat used a wet tank as a 'cacca box'; another used plastic tubs containing sea water that was changed regularly.

The position of the 'cacca box' on the fishing boats varied, most being below the tipper; others were on the opposite side of the deck to the tipper or amidships. On 14 of the 115 boats monitored, the 'cacca box' was beneath a coachtop (wheelhouse roof) extension, which provided some shade.

Several fishermen stated that when they were catching large numbers of rock lobsters they would sort every 3 to 5 pots (sequence 4) or whenever their 'cacca box' was full, rather than using sort sequences 1,2 or 3 when catching reduced numbers.

The number of persons involved in sorting the rock lobsters greatly affected the time taken to empty the pot or the 'cacca box'. There were several different combinations of crew involved in sorting:

1. Skipper sorting only.

2. A deck-hand sorting only.

3. Both the skipper and deck-hand sorting.

4. Two or more deck-hands sorting.

5. One deck-hand sorting continuously during periods of high catch, on boats which employ two or more deck-hands (e.g. during the 'whites' phase of the fishery).

Sorting directly from the pot (sequence 1) was observed on many occasions with pot type 2 (batten) when low catch rates were experienced.

It was observed on several occasions that undersize that were close to size would be held for extended periods of time, until the skipper himself could gauge them and decide whether they were size or undersize. Usually only small numbers of animals were involved, but this procedure may increase exposure times for sorting methods that normally do not have extended exposure periods (e.g. sequences 1 and 2). This was also noted by Brown et al. (in press).

Boats fishing in amongst breakers (white water), as often occurs with jet boats working the Abrolhos Islands, were observed to change sorting methods in different situations. They would switch from their normal sorting sequences 1,2 or 3 to 4 or 5, while working in difficult areas.

The distances that undersize rock lobsters were displaced was difficult to estimate. Some fishermen took great care to return the undersize back into the area from where they were captured, which unfortunately in some cases resulted in slightly increased exposure times.

IV DISCUSSION

The objective of the current study was to compare the proportion of fishermen currently (1983-84) using each of the sorting methods to the proportion observed in the initial study (1977-80). This would determine whether the large-scale education programme undertaken by the Fisheries Department (1981-82), to alert fishermen to the effects of poor handling practices on the survival of undersize, had helped to significantly change the sorting methods used and thereby reduce the mortality of handled undersize. From these results further recommendations to improve undersize survival could be made.

For the two studies to be directly comparable it was essential that the current study followed the methods of the initial study as closely as possible. Brown et al. (in press) sampled 15% of the fishing fleet, at seven anchorages: Kalbarri, Abrolhos Islands, Dongara-Cliff Head, Jurien Bay, Ledge Point, Two Rocks and Fremantle, over three seasons, 1977-78, 1978-79 and 1979-80, and this was considered representative of the entire fishery. The current study can also be considered representative of the fishery, as 15.0% of the commercial fleet was sampled over one season from almost the entire area fished by the rock lobster fleet. The sample involved a random selection of fishermen working in depths where the possibility of catching undersize was greatest, i.e. in depths less than 36 m (20 fms) (Brown and Caputi, 1983; Brown et al. in press). All fishermen approached were most co-operative and willingly took research staff aboard their vessels.

As with the initial study, the analytical techniques used in this study could give rise to bias in a number of areas (Brown et al. in press):

1. The first possible source of bias is that the proportion of fishermen observed in the current study using the continuous sorting methods may be underestimated and the sorting after each pot method may be overestimated compared to the initial study. This is because the initial study sampled more heavily during periods of high catch rates (November-December and March-April) when the largest numbers of undersize are caught. When catch rates are high, fishermen are likely to change from sorting

after each pot to continuous sorting, because they are not able to keep pace with the large number of animals coming aboard. This would tend to underestimate the average exposure time calculated for undersize.

2. The second possible source of bias runs counter to that described in 1 above. Fishermen who fish exclusively beehive pots (pot type 1) were under-represented in the current study (see research log book data Table 3). These fishermen predominantly sort direct from the pot (sort type 1) which gives the shortest exposure period of any of the sorting techniques (Tables 7 and 8).

   The second source of bias would offset to some degree the increase in exposure time caused by underestimating the continuous sorting method during periods of high catch rate discussed in 1 above. Therefore it is considered that the results are generally representative of the commercial rock lobster fleet.

The results of the current study show that approximately 4.0% of the undersize handled by fishermen, are exposed for more than fifteen minutes (Table 6A). This percentage is a marked reduction on the 16.5% exposed for more than fifteen minutes as determined in the initial study (Table 6B). The reason for this reduction can be directly attributed to improvement in sorting methods. In the initial study the greatest proportion of fishermen 37.6% sorted after pulling a line of pots (end of line sorting-sequence 5) and 9.5% sorted after relaying a line of pots (sequence 6), which resulted in extended periods of exposure for the undersize (Table 6B). The current study found the greatest proportion of fishermen now sort after each pot or continuously, with approximately 82% of the fishermen employing these two sorting methods (Table 6A).

Exposure, damage and displacement, the three major factors contributing to fishery induced mortality (Brown and Caputi, 1983; Brown et al. in press), could be reduced to the lowest possible level if sorting direct from the pot and sorting after each pot were the sorting methods used by all fishermen. In the initial study, approximately 20% of fishermen used these two sorting methods (Table 6B); now approximately 47% of fishermen use these two methods (Table 6A).

Comparing exposure times for each sorting method in both studies, it can be seen that the percentages of undersize (Tables 6A and 6B) sorted in each five minute time period are very similar. This suggests that the fishermen using each method are sorting as fast as is practicable. If previously they had not been sorting as fast as practicable and they had since increased the speed of their operation, it could be expected that a greater percentage of undersize would be sorted over the same time period. This was not found to be the case.

A factor that may have contributed to the observed changes in the proportion of fishermen using the various sorting methods, could be the changes in pot types, away from exclusively beehive pots to combinations of beehive and batten or only batten (Tables 2 and 3). However, as previously stated, fishermen using beehive pots predominantly sort directly from the pot and some of them appear to have continued this practice with their new gear (batten pots), as the proportion of fishermen sorting directly from the pot has in fact increased during the period between the two studies.

An additional factor that may have caused an overestimate in the change from longer to shorter sorting methods, is that, unlike the initial study, conducted over 3 seasons, the current study was conducted over 1 season and could not concentrate monitoring on the periods of highest catch rate. In the current study 12 boats (10%) were monitored during the period November-January, the 'whites' fishery, and period of highest catch rates, while in the initial study 53 boats (42%) (Brown et al. in press) were monitored during the same period. This could have led in the current study, to an overestimate of the proportion of fishermen using the first two sorting methods (Table 6A), which give the shortest exposures. During periods of high catch rates a proportion of the fishermen observed using sequences 1 and 2 would have reverted to one of the methods giving considerably longer exposures (usually continuous sorting - sequence 3). An example of this is fishermen who use sorting after each pot during periods of low catch rates and continuous sorting during periods of high catch rate. Therefore the size of the change to sorting direct from each pot and sorting after each pot may not be as large as it appears, especially for the latter method. Therefore the improvement in handling methods and hence survival of undersize observed in this study should be viewed as the maximum improvement in handling practices that would have occurred.

As in the initial study, no trends linking sorting techniques with particular boat types, license sizes or ethnic groups was found. No sorting method resulted in a significantly faster rate of handling gear (the average time to pull, empty, rebait and stack a pot was approximately two minutes in shallow water).

V CONCLUSIONS

As a follow-up to the initial study of Brown _et al_. (in press), the current study has shown that there has been a significant improvement in fishermen's attitudes towards handling undersize (despite the possible sources of bias outlined above). This has led to 87.5% of all undersize being handled within 15 minutes compared to 65% in 1977-80. The changes can largely be attributed to the extensive education programmes that have been run by the Fisheries Department.

As stated in Brown _et al_. (in press), the most significant factor in determining sorting methods was clearly the attitude of the fishermen, and this is still the case.

Although the changes have led to a significant improvement in handling practices, with many fishermen changing to sorting after each pot, less than half (47.8%) of those sampled were sorting direct from the pot or after each pot, i.e. the two sorting methods that minimize mortality due to handling. The remaining fishermen (52.2%) used a method that could cause significant mortality. Some of the large group of fishermen who sort continuously (42.6%) may return most of their undersize to the water as quickly as those who sort after each pot when catch rates are low. However, when catch rates are high, the continuous sorting method cannot keep up with the constant addition of more animals to the 'cacca box', and under these conditions fishermen who sort continuously will give the undersize longer exposures and hence produce significant mortalities. Notwithstanding the improvements that have occurred in handling practices, the mortality that could be occurring (i.e. even if only at the rate of 25% of the mortalities that were occurring before the education programme was initiated), the losses would still be in excess of $A3 million annually (1984-85 prices).

Recommendations to Further Reduce Fishery Induced Mortality

1. Design of a new escape gap that will significantly reduce the number of undersize brought on board. Quite obviously the root of the problem is that rock lobsters which are too small for sale are retained unnecessarily in the pot and taken from their sea floor environment and exposed out of the water on the deck of a boat. Reducing the capture of undersize (through a more effective escape escape gap) should be seen as a first priority. This has been the subject of a separate investigation.

2. The second priority, is that any undersize captured should be returned to the water in the shortest possible time (i.e. by sorting all the animals from one pot before the next pot is pulled). There are only two sorting methods which guarantee to minimise losses due to handling: (a)

sorting directly from the pot and (b) sorting immediately after the pot has been emptied. In each case all the lobsters, both size and undersize, are sorted from one pot before the next pot is pulled.

3. The third priority is that during any brief stay onboard the undersize should be kept under the best possible conditions. Sprays should be fitted around the top of the 'cacca box', so the lobsters are kept cool and wet while sorting takes place.

4. See Brown _et al_. (in press) for other recommendations.

VI ACKNOWLEDGEMENTS

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VII REFERENCES

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TABLE 1

THE NUMBER OF ROCK LOBSTER BOATS MONITORED FROM EACH ANCHORAGE ON THE WESTERN AUSTRALIAN COAST AND THE MONTHS DURING WHICH MONITORING OCCURRED.

ANCHORAGE	NO. OF BOATS SAMPLED		MONTH	
KALBARRI		11		MAY
PORT GREGORY		4		MAY
RAT ISLAND	(6)*	10	(MARCH)*	APRIL
LITTLE BAY		4		MAY
HORROCKS		1		MAY
GERALDTON		6		APRIL
DONGARA		9		FEBRUARY
SANDY CAPE (POINT)		2		MARCH
JURIEN BAY	(3)	5	(FEBRUARY)	MARCH
CERVANTES		21		MARCH
LANCELIN	(6)	1	(DECEMBER)	APRIL
LEDGE POINT	(1)	5	(DECEMBER)	APRIL
TWO ROCKS		11		JANUARY
QUINNS ROCK		1		JANUARY
WHITFORDS	(1)	2	(DECEMBER)	FEBRUARY
FREMANTLE	(1)	3	(NOVEMBER)	FEBRUARY
SAFETY BAY		1		JANUARY
TOTAL		115		

* NUMBERS IN BRACKETS REFER TO MONTHS IN BRACKETS AND ARE INCLUDED IN THE TOTAL.

TABLE 2

NUMBERS OF MONITORED FISHING BOATS UTILIZING EACH POT TYPE/COMBINATION AT EACH ANCHORAGE. TOTALS ARE COMPARED WITH PREVIOUS RESULTS.

ANCHORAGE	POT TYPE*						
	1	2	3	4	5	6	7
KALBARRI		8					3
PORT GREGORY		4					
RAT ISLAND		15					1
LITTLE BAY AND HORROCKS		5					
GERALDTON		6					
DONGARA		9					
SANDY CAPE AND JURIEN BAY		8		1			1
CERVANTES		17		2	1		1
LANCELIN		5			1		1
LEDGE POINT		3			3		
TWO ROCKS	1	3		1	3	2	1
QUINNS ROCK				1			
WHITFORDS		1		1			1
FREMANTLE				1		3	
SAFETY BAY				1			
TOTALS Σ = 115	1	84	0	8	8	5	9
AS PERCENTAGE OF SAMPLE (NEAREST WHOLE PERCENT)	1	73	0	7	7	4	8
INITIAL STUDY RESULTS	33	63	0	3	1	0	0

*POT TYPE:
1. Beehive or stick pot.
2. Batten or slat pot.
3. Steel pot.
4. Combination of beehive and batten pots.
5. Combination of beehive, batten and steel pots.
6. Combination of beehive and steel pots.
7. Combination of batten and steel pots.

TABLE 3

NUMBERS OF FISHING BOATS, FROM DECEMBER 1983 LOG BOOK RETURNS, UTILIZING EACH POT TYPE AT EACH ANCHORAGE.

ANCHORAGE	POT TYPE*						
	1	2	3	4	5	6	7
KALBARRI		2			1		
PORT GREGORY		3					
LITTLE BAY AND HORROCKS		3					
GERALDTON	2	22	1	1			
DONGARA TO BEAGLE IS.	2	49					
BEAGLE IS. TO SANDY CAPE	2	13		1			
SANDY CAPE AND JURIEN BAY	2	8		1			2
CERVANTES AND GREEN IS.		13					
WEDGE IS. AND LANCELIN		16		2			
LEDGE POINT		5		1			
SEABIRD	3						
TWO ROCKS	12	11		1			
QUINNS ROCK				1			
WHITFORDS		2					
FREMANTLE	6			3			
SAFETY BAY	1	1		1			
MANDURAH AND SOUTH							
TOTALS Σ = 194	30	148	1	12	1	0	2
TOTALS AS A PERCENTAGE (NEAREST WHOLE PERCENT)	16	76	1	6	1	0	1

* FOR POT TYPE DESCRIPTIONS, REFER TO TABLE 2

TABLE 4

NUMBERS OF BOATS AT EACH ANCHORAGE USING SPECIFIED METHODS. TOTALS HAVE BEEN COMPARED WITH EARLIER RESULTS.

ANCHORAGE	SORTING METHOD*					
	1	2	3	4	5	6
KALBARRI		4	7			
PORT GREGORY	2	1	1			
RAT ISLAND		6	10			
LITTLE BAY HORROCKS		2	3			
GERALDTON		3	3			
DONGARA		4	5			
SANDY CAPE AND JURIEN BAY	1	8	1			
CERVANTES	3	8	6	2	2	
LANCELIN		2	4	1		
LEDGE POINT		2	1	2	1	
TWO ROCKS		2	6		3	
QUINNS ROCK	1					
WHITFORDS	1	2				
FREMANTLE	1	1	2			
SAFETY BAY		1				
TOTALS Σ = 115	9	46	49	5	6	0
AS PERCENTAGE OF SAMPLE	7.8	40.0	42.6	4.4	5.2	0
INITIAL STUDY RESULTS	5.6	15.2	27.2	4.8	37.6	9.6

*SORTING METHOD:
1. Sorting directly from the pot.
2. Sorting after each pot.
3. Sorting continuously.
4. Erratic sorting.
5. Sorting at the end of a line of pots.
6. Sorting after relaying a line of pots.

TABLE 5

NUMBERS OF BOATS MONITORED, POT TYPE(S) USED AND SORTING METHOD(S) EMPLOYED.

POT TYPE	SORTING METHOD 1		2		3		4		5	
1					1	(0.87%)				
2	5	(4.34%)	36	(31.30%)	37	(32.17%)	3	(2.61%)	3	(2.61%)
3										
4	1	(0.87%)	6	(5.22%)	1	(0.87%)				
5			1	(0.87%)	4	(3.48%)	1	(0.87%)	2	(1.74%)
6	1	(0.87%)			3	(2.61%)			1	(0.87%)
7	1	(0.87%)	4	(3.48%)	3	(2.61%)	1	(0.87%)		

Refer to Results section for a detailed description of sorting methods and Table 2 for pot types.

Table 6: Percentage of boats and undersize sorted and exposure time for each sorting method for (A) the initial study and (B) the current study

A. Current study (1983-84)

Sorting methods*	Percent of boats	Percent undersize sorted	Exposure times (minutes) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45 plus
Direct from pot	7.8	7.8	99.0	0.5	x	x						
After each pot	40.0	40.4	97.0	1.0	0.5	0.5	x	x	x	x		
Continuous	42.6	43.5	85.5	7.0	3.5	1.5	1.0	0.5	0.5	0.5	x	x
Erratic	4.4	4.5	52.0	14.5	17.0	10.5	0.5	1.5	1.0	0.5	0.5	2.5
At end of line of pots	5.2	3.9	47.0	23.0	15.5	9.5	4.5	0.5	x			
After relaying pots	0	0										
All boats and sorting methods combined	100	100	87.5	5.0	3.5	2.0	0.5	0.5	x	x	x	0.5

B. Initial study (1977-80)

Sorting methods*	Percent of boats	Percent undersize sorted	Exposure times (minutes) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45 plus
Direct from pot	5.6	6.4	100	x								
After each pot	15.2	13.0	99.0	1	x							
Continuous	27.2	26.2	86.0	7.5	3.5	1.5	1.0	0.5	x			
Erratic	4.8	4.5	63.0	16.0	10.0	7.0	2.5	1.0	0.5	x		
At end of line of pots	37.6	40.9	42.0	17.5	13.0	8.5	6.5	4.0	3.0	1.0	1.0	2.5
After relaying pots	9.6	9.0	34.0	11.0	10.0	9.5	10.0	6.0	6.0	3.5	3.0	6.0
All boats and sorting methods combined	100	100	65.0	11.0	7.5	5.0	4.0	2.5	2.0	1.0	1.0	1.0

x = less than 0.25
* see Methods for complete details of sorting methods

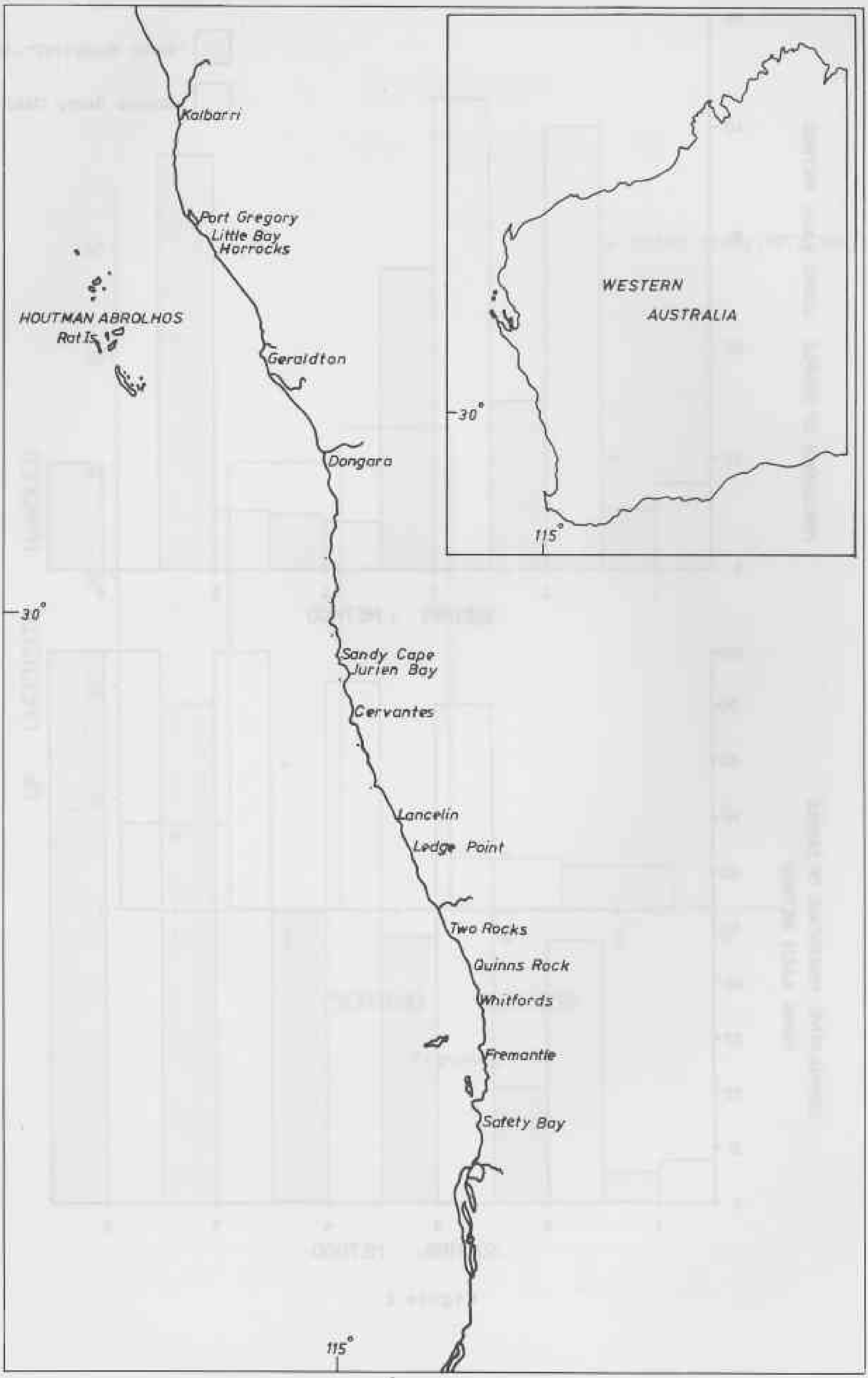
Kalbarri
Port Gregory
Little Bay
Horrocks
HOUTMAN ABROLHOS
Rat Is.
Geraldton
Dongara
30°
Sandy Cape
Jurien Bay
Cervantes
Lancelin
Ledge Point
Two Rocks
Quinns Rock
Whitfords
Fremantle
Safety Bay
115°
WESTERN
AUSTRALIA
30°
115°

Figure 1

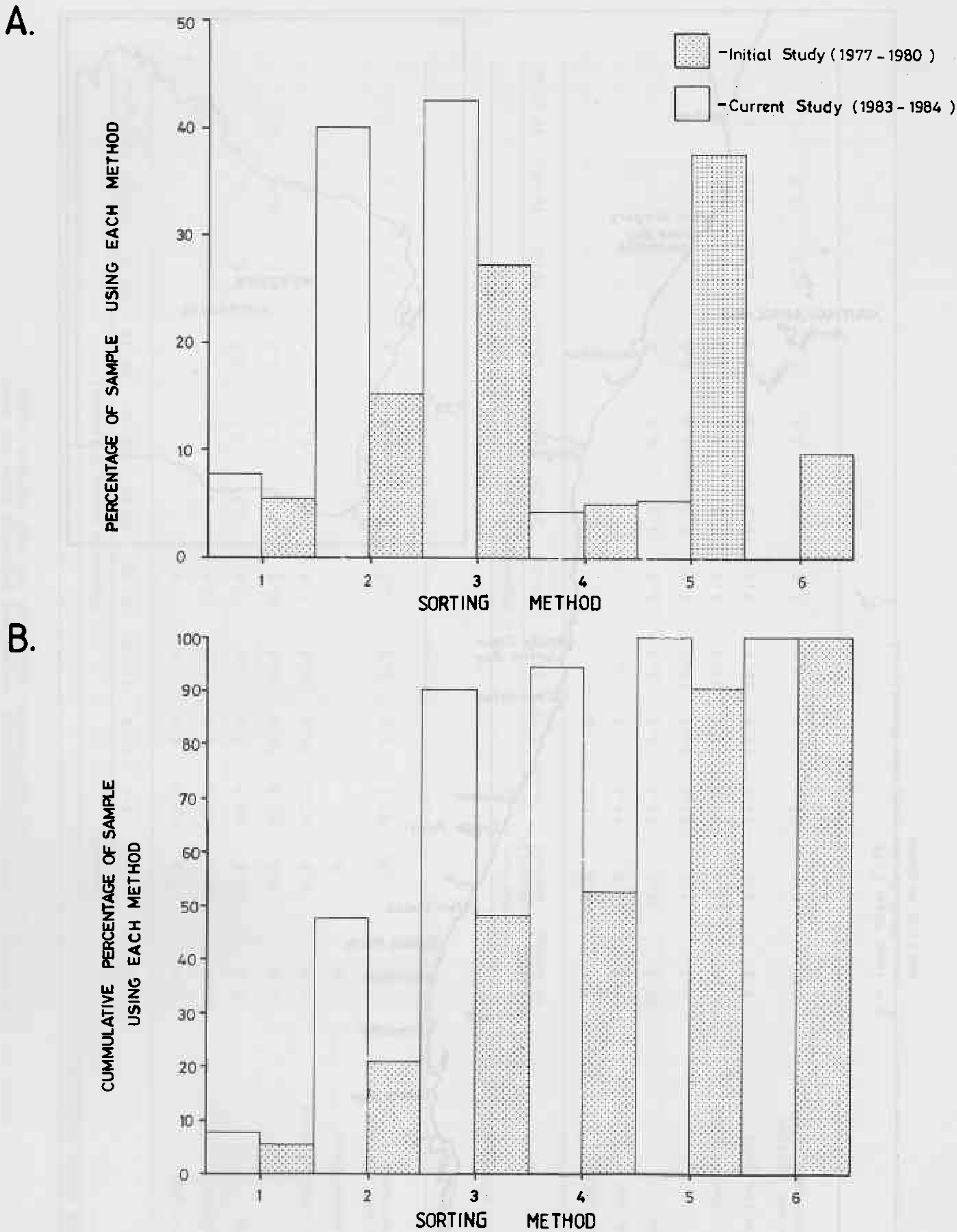
A.
PERCENTAGE OF SAMPLE USING EACH METHOD
50
40
30
20
10
0
–Initial Study (1977 – 1980)
–Current Study (1983 – 1984)
1
2
3
4
5
6
SORTING METHOD
B.
CUMMULATIVE PERCENTAGE OF SAMPLE USING EACH METHOD
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
SORTING METHOD

Figure 2

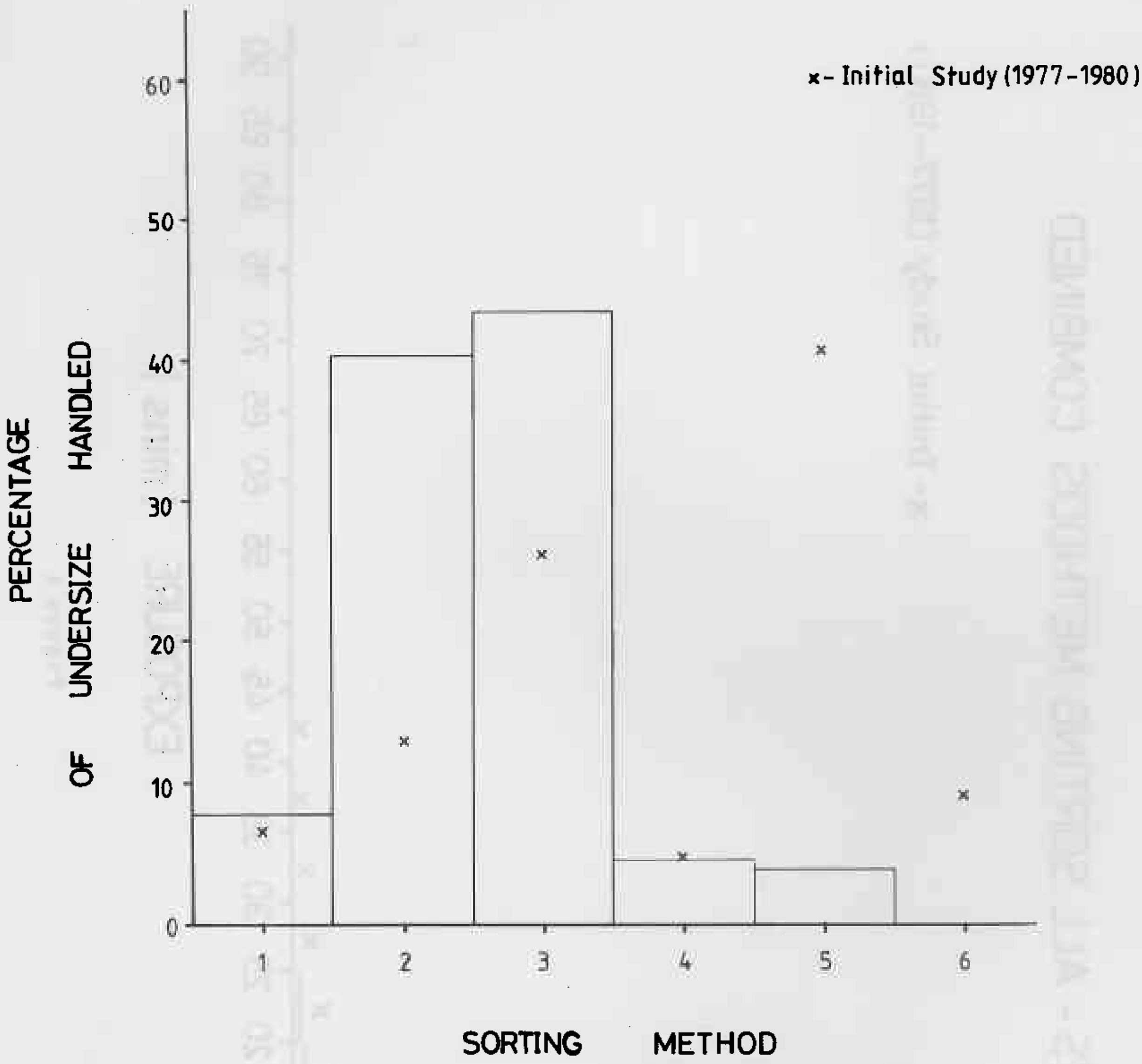
x- Initial Study (1977-1980)
PERCENTAGE OF UNDERSIZE HANDLED
SORTING METHOD
60
50
40
30
20
10
0
1
2
3
4
5
6

Figure 3

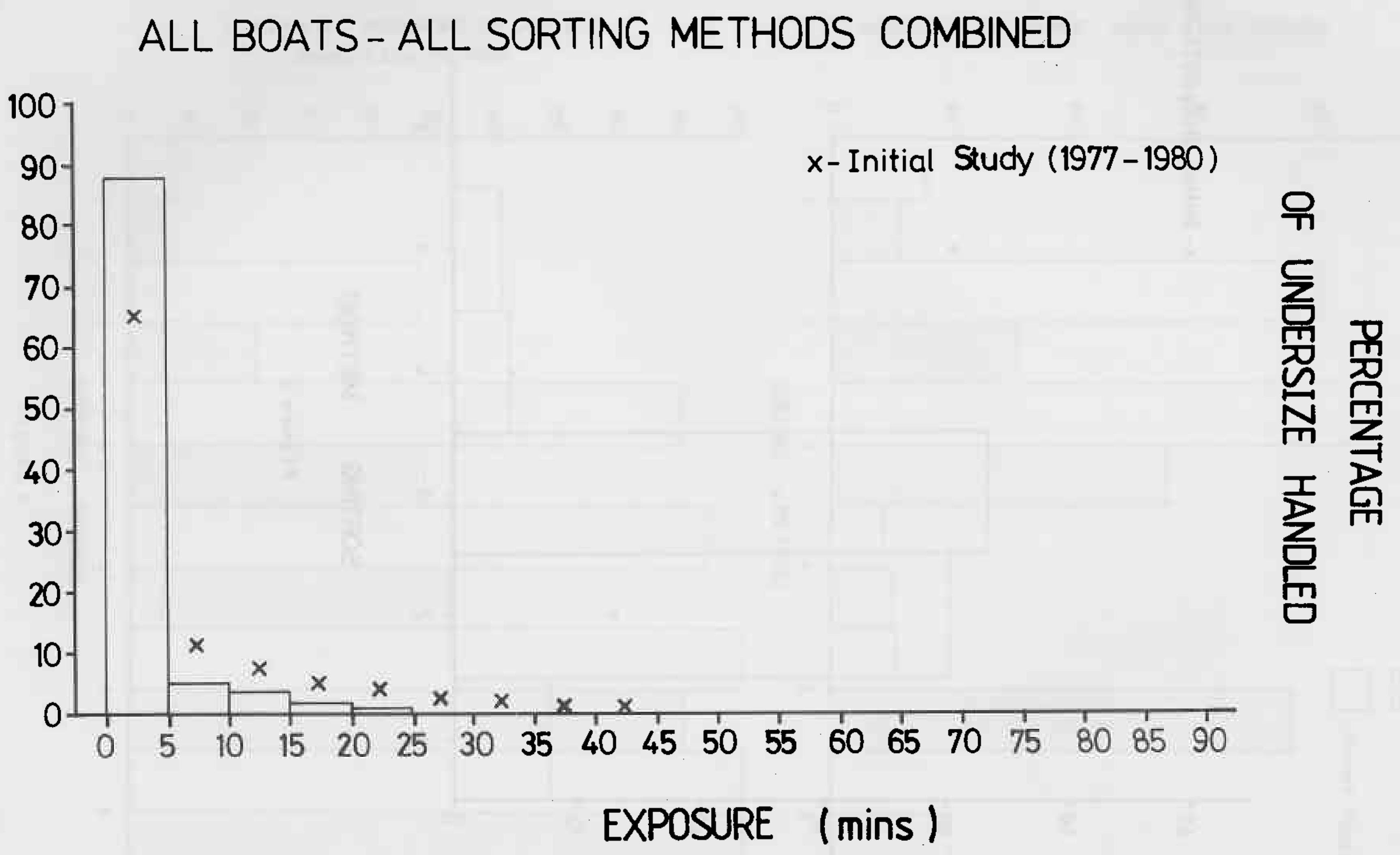
ALL BOATS - ALL SORTING METHODS COMBINED
x - Initial Study (1977 - 1980)
PERCENTAGE OF UNDERSIZE HANDLED
100
90
80
70
60
50
40
30
20
10
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
EXPOSURE (mins)

Figure 4