# Research Activities Report for the Project

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# Research Activities Report for the Project:
# Living Aquatic Resources - management and knowledge base
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# Summary


### Project Approach

The research reported here examines local ecological knowledge (LEK) and its potential contributions to building a knowledge base within a cooperative, co-management approach to fisheries management. It examines this issue in two contexts: the artisanal fishery in the Sedone River in Southern Laos and the shrimp fishery in Dam Doi Province in Viet Nam. The central conceptual device used in the research is the "simple indicator of the health of fish stocks". These simple indicators are the focal point around which we examine the contribution of LEK to management. We begin from the premise, however, that even with an indicator approach the question of including LEK in fisheries management is problematic. For LEK to contribute to management we must have some collective understanding of what kinds of knowledge make up LEK, to what extent is this knowledge shared both within and among different user groups, and how this knowledge is used (and abused) in debates around the use and control of the fisheries resource.

The research began with conversations between trained researchers and local fishermen which produced ideas about simple indicators of the health of fish stocks. The biological teams then subjected these indicators to a biological evaluation while the social science teams examined a) the degree to which there was a consensus among the fishers about their LEK and b) the degree to which environmental, economic and institutional differences among stakeholders influenced their perspective on the LEK and the role of the indicators.

Four social science methods were used in this research: In-depth interviews; consensus analysis; pile sorts and Q-sorts. In-depth interviews and consensus analysis were carried out in both Laos and Viet Nam. Pile sorts were carried out only in Laos, while q-sorts were carried out only in Viet Nam. Both biologists and social scientists participated in the in-depth interviews. The biologists then proceeded to evaluate the statements made by fishers in the interviews in light of already existing biological information about the fisheries. The consensus analyses, pile sorts and Q-sorts were use by the social scientists to evaluate the degree to which the fishers agreed among themselves about the information provided in the interviews. They were also used to score fishers on their individual level of expertise in LEK. The social scientists then proceed to search for systematic patterns in both agreement and level of expertise among the fishers.

### Summary of Results

A shared local ecological knowledge was found to exist on both the lower Sedone River and Dam Doi shrimp fishery. But our attempt to classify statements and find systematic differences in levels of knowledge about fish abundance, fish habitat, or fish behaviour failed. Whether this failure is based on substance or methodology, the implication is that we do not know how to categorize LEK in a way that is useful for quickly developing management-related indicators.

The fishers with the highest level of LEK are the fishers who fish using smaller gears that are, in fact, frowned upon by the government fisheries managers. This result is clearer in Dam Doi, where the comparison is between smaller stationary gears, large stationary gears, and large mobile gears, than it is in Laos, where the trap fishers have slightly more LEK than the

other artisanal fishers, but where using more types of gear has an even greater influence on levels of LEK.

Many specific ideas for indicators were subject to both sociological and biological evaluation. In Laos, indicators related to catch composition (fish size and species diversity) has the best fit. In fact, this is likely the only kind of indicators where the proportions of correct answers about the indicators by the fishers were high enough to be usefully reliable. For the Dam Doi inshore fishers the most reliable observations were those related to salinity, the geographical distribution of the shrimp, wind and spawning behaviour. The Dam Doi offshore fishers are fairly similar to the inshore fishers but their highest proportion correct is not very high.

In general, as would be expected, higher scores are found for those natural conditions which appear similar across wide areas. In Laos these conditions attach more to the stocks with such things as fish size and diversity, catch changes, spawning behaviour rather than to the environment because environmental conditions along the river are so varied. This is an important contrast with the fact that the Laotian fishers consider environmental conditions important as an indicator of fish abundance. In Viet Nam the more general conditions are environmental, e.g. salinity, temperature, and not as much indicators of the condition of the stocks changes, although catch rates showed borderline reliability among the inshore fishers.

As far as political influence on the understanding of the indicators is concerned, in Laos there does not seem to be as sharp a split as is found in Viet Nam. At least this is true among the stakeholders directly related to fishing, it may not be true among other groups wishing to make use of Laotian rivers for water or power. In Viet Nam the divisions in terms of both knowledge and management options are more stark. Both habitat and fishing techniques are areas of disagreement. There is a fairly dominant discourse among the non-fisher respondents that supports new technology and places the blame for the fall in shrimp production on over-fishing inshore by small boats. This same basic position reflects the beliefs of many fishers as well, but another group of fishers sees the mesh sizes being used as the main problem.

Among the potential indicators where the LEK is the most reliable, as measured by degree of consensus, it is spawning and geographical distribution that are the most relevant to management discussions. The idea of protecting spawning shrimp is seen as both feasible and biologically reasonable from the LEK perspective. The protection of spawning areas is also related to the main disagreement among fishers: the role that mangrove forests play in protecting juvenile shrimp. This is expressed in disagreement over the purpose of the main government policy programme, the Integrated Mangrove and Aquaculture Model. Offshore fishers and fishing communities are very concerned that this habitat be protected and see this as the main purpose of the programme. Inshore fishers and fishing communities, on the other hand, see it more as an aquaculture development programme. It is unlikely that there would be any agreement about using the extent of the mangrove forests as an indicator of fisheries health.

In Dam Doi, biological analysis included comparing statements from the interviews with biological data gathered by official enumerators. The enumerator data indicates that a little over half, or five of the eight statements that could be most clearly evaluated, had good agreement within the fishermen's statement groups.

The case study in the Sedone River shows that it is possible to gather information about the fishery and the condition of the river. This information may be used in the management system to issue regulations to protect the fish and secure a degree of sustainability in the fisheries. It is also clear that a fisheries management based on indicators of ecosystem condition evaluated by local knowledge is prone to make serious mistakes. Due to the lack of scientifically proven information of the fishes in the Mekong system, it is not possible to test the quality of the information provided by LEK, but ongoing attempts to provide time series of CPUE-data for several important species, may provide such information in the near future.

**Main Conclusions**

Interviewing local fishers can be a method of obtaining basic information about the fishery and the resource, but this information is too weak to constitute the exclusive basis of management decisions. There is a rough consensus about conditions in the fishery among the fishers but that the degree of consensus is highly variable. In general, higher consensus is found in reference to those natural conditions which appear similar across wide areas. The main, practical conclusion of the present research is that using simple indicators for management does not substitute for ongoing interactions between scientists and fishers where management goals are set and refined. Such interactions must include the identification and re-identification of indicators that tell the stakeholders when those goals are reached. Indicators are part of a larger process and cannot be understood when abstracted from that process.

# Introduction

The research reported here examines local ecological knowledge (LEK) and its potential contributions to building a knowledge base within a cooperative, co-management approach to fisheries management. The central conceptual device used in the research is the "simple indicator of the health of fish stocks". These simple indicators are the focal point around which we examine the contribution of LEK to management. This approach contrasts with the assumption that fisheries management should be carried on in a particular way, such as the traditional stock assessment model followed by catch restrictions, and that LEK should be examined from the perspective of how it can contribute to the knowledge base of this prepackaged approach. The simple indicators are devices that can emerge from LEK, or from discussions between LEK and formally trained scientists, that can be the basis of management decisions. Most of these indicators are established ideas in fisheries management. Their use here, however, is not as something one picks from a text book and applies to a fishery, instead the point of the simple indicators is that they have the potential to be developed cooperatively by stakeholders as a basis for understanding the condition of that fishery and how management can respond to that condition. We do not take this final step of developing them as the basis of management of the fisheries we examine. The stakeholders are the ones who have to do that. Rather we examine LEK from the indicator perspective in order to learn some basic lessons about the potentials and pitfalls of involving LEK in cooperative management.

We begin from the premise that even with an indicator approach the question of including LEK in fisheries management is problematic. For LEK to contribute to management we must have some collective understanding of what kinds of knowledge make up LEK, to what extent is this knowledge shared both within and among different user groups, and how this knowledge is used (and abused) in debates around the use and control of the fisheries resource. We do not have complete answers to these questions to offer. Indeed, a great deal of our effort has gone in to beginning the task of developing methods to answer these questions. Nevertheless, we have developed, from both a biological and a sociological viewpoint, some initial pictures of the role of LEK and potential indicators in management debates in specific fisheries that are worth sharing with other natural resource management partitioners and scholars.

The research began with conversations between trained researchers and local fishermen which produced ideas about simple indicators of the health of fish stocks. The biological teams then subjected these indicators to a biological evaluation while the social science teams a) examined the degree to which there was a consensus among the fishers about their LEK and b) the degree to which environmental, economic and institutional differences among stakeholders influenced their perspective on the LEK and the role of the indicators. We examine LEK in two practical contexts: the artisanal fishery in the Sedone River in Southern Laos and the shrimp fishery in Dam Doi Province in Viet Nam.

# 1. Research Methods

Four methods were used in this research: In-depth interviews; consensus analysis; pile sorts and Q-sorts. In-depth interviews and consensus analysis were carried out both Laos and Viet Nam. Pile sorts were only carried out in Laos, while q-sorts were only carried out in Viet Nam.

## *1.1 In-depth Interviews*

Research in both cases was initiated by holding long conversations with fishers, as well as a small number of fish traders and government officers, about the kinds of things they were seeing and learning about the fisheries and their habitats in the areas where they were fishing. These interviews are designed to illuminate the concepts and categories that the fishers themselves use to understand the fishery and its environment. They begin with general discussions of time lines and maps because these are well known techniques that allow the discussion to be framed in respondents terms in ways that simply responding to specific questions does not. The interviews are structured so that the discussions become more specific as the interview progresses.

These conversations lasted from one to two hours. They were recorded on tape and then transcribed and translated. The statements that fishers made during these interviews were the basis of further research. On the biological side the transcripts were studied for clues to help identify candidates for simple and understandable indicators of ecosystem health. On the social side statements were isolated for use in further interviewing. Simple, factual statements about the fishery and the environment were identified for use in the consensus analysis and more complex statements were identified to be used in sorting.

The guidelines used for these interviews are included as Appendix One.

## *1.2 Methods for the Social Science Evaluation of the Candidate Indicators*

The social science evaluation of the candidate indicators is tasked by the work plan to implement a discourse analysis that will illuminate how claims about the ecological relationships implied by the indicators are used in debates over control of the resources. We interpreted this broadly as meaning that we needed to both describe the discussion about fisheries management in general among the relevant stakeholders. This means explaining how the different stakeholders see the resource, the categories they used to understand what they are seeing and then how they related these understandings to the main issues in the management of their fishery. Having accomplished such a description, we then needed to evaluate how claims both directly and indirectly related to possible indicators were being used in these debates.

The extent to which we could use the indicators directly in accomplishing the general description of the debate is limited by two things. The first is that the methods must build off of what the fishers actually say if we are to try to characterise their ways of understanding the fishery. Indicators developed for management purposes are not things that arise spontaneously from the way stakeholders, particularly user groups, describe the resource. The second is that the methods, particularly the sorting methods, derive their power from asking respondents to situate different aspects of the debate in respect to the whole debate.

Hence, the selection of the statements was primarily made to try to be representative of the main points raised by the fishers, so that the overall LEK and its relationship to economics and management politics could be assessed. Having this comprehensive picture would, in turn, make it possible to place the candidate indicators in their proper context. Nevertheless, a number of the statements are related directly to the candidate indicators. This makes possible an initial assessment of how well fishers agree about observations related to the indicators.

### *1.2.1 Consensus Analysis*

The basic idea of consensus analysis is that if fishers have and are able to communicate valid information about the environment then fishers working in similar areas will agree in their answers to the questions. Agreement is seen as an indicator of the validity of the observations.

The idea that the degree of consensus is a measure of the reliability of local knowledge is derived from research within the anthropology of knowledge. Romney et al. (1986) offer a useful model for research into culture knowledge in general, and into LEK in particular, that has been used in fisheries LEK research (Boster and Johnson 1989, Guest 2002). A matrix of agreements and disagreements between a fairly small number of respondents to a set of questions is subjected to a factor analysis. If there is a general consensus it will appear in the form of a large amount of variance being explained by one factor while and all the other factors are comparatively tiny if this is not the pattern then some form of systematic disagreement exists. The application of the model to LEK makes the robust assumption that this one factor reflects people's common experience of a natural phenomenon.

The procedure is to select a set of twenty or more dichotomous (i.e., having exactly two possible answers) factual questions about the resource. These questions will be things that fishers and others told us in the initial interviews. Some editing is of these questions is done. Most importantly simple, factual assertions are isolated from a larger discussion that may involve statements about the implications of these facts or their relationship with other facts. No complex statements are used in the consensus analysis, they are analysed by the sorting procedures discussed below. About a third of the statements are 'negated' meaning that they are changed to mean their opposite. The reason for this is that we assume that most of the statements made by the fishers will be true, which means that if we did not negate any statements the fishers would be responding 'agree' over and over again, leading to rote responses. We explained this negation to respondents and asked them to listen carefully to the questions as they were actually read.

The responses to these questions are then tested using statistical procedures to see if there is a consensus among respondents, in other words to see if the responses fit the "cultural consensus model." The cultural consensus model means that 1) that respondents agree with each other to a very high degree and that 2) there is only one thing that is exerting any significant influence on their responses. If the model does not fit, it means that something else besides what they actually see in nature is having an important influence on their answers.

Consensus data are entered and stored in a simple matrix of respondent by responses to questions. The statistical analysis is done on a respondent by respondent matrix of similarities, i.e. the proportion of questions that they answered the same way. A factor analysis of this matrix yields "eigenvalues." The largest eigenvalue tells us, following our basic theory, the percentage of the variance in the matrix that is accounted for by respondents observing the same thing in the world. If there is another large eigenvalue, then that indicates that there is another important pattern that is influencing their responses. If such a pattern exists then it must represent some sort of underlying bias that is producing the pattern. We test this by comparing the first and second eigenvalue, the rule of thumb is that if the first eigenvalue is not at least three times as large as the second eigenvalue then no consensus exists among respondents. When this second eigenvalue is large relative to the first one it may represent some systematic bias that comes, for example, from different stakeholders seeing the world differently. It may also come from the systematic bias introduced when some of the questions are difficult and unclear. If we do not have a consensus we can experiment with the data to see if we can find the underlying cause. It is, of course, best if this underlying cause is not poorly chosen or formed questions.

If the model is a correct fit then it is possible to generate from the similarity data two more pieces of information. The first is a measure of competence for each fisher, i.e. how well each fisher understands the cultural consensus. The second is the estimation of the correct answers (i.e. correct from the local ecological knowledge perspective as calculated here, this is the restricted meaning given to terms like "correct" and "right" in the remainder of the report ) for all the questions. Although these estimations of correct answers begin with what the majority of fishers said, the calculation is iteratively weighted by individual fishers competence. Because the model estimates both this competence measure and correct answers to the questions, we can them examine various characteristics of the fishers to see if we can identify groups of fishers who have greater or lesser LEK expertise. This can be done by examining the variation of either the competence measure generated by the model or the proportion of questions that a fisher answered correctly. These two variables are highly correlated, indeed they are iteratively calculated from one another, and give essentially the same results. In the interests of simplicity and ease of interpretation, we will report the results for the proportion of questions that a fisher answered correctly[1].

### *1.2.2 Pile Sorts*

Pile sorts consist of asking respondents to group objects according to whatever criteria they please. The sorts of different groups are then compared in hopes of uncovering insights into the differing ways the groups view the objects. Two kinds of pile sorts are common. Constrained pile sorts require the respondents to create piles of particular sizes while unconstrained sorts allow the respondents to classify the objects in any way they please. We used unconstrained pile sorts as this gives the respondents the maximum freedom to express how they see the relationships between the objects.

The focus of the analysis of the pile sorts is the frequency, across groups of respondents, with which any two objects appear in the same pile. This frequency is then translated into

[1]Throughout the discussion these measurements are referred to as the level or degree of LEK that a respondent has. This is clearly a methodological reification of a very imperfect measurement. Unfortunately we have no good way to judge the validity and reliability of this measure of "level of LEK" beyond it repeated use in this study. The reader will have to consider this and make his or her own judgements about this measurement in light of the coherence, or lack thereof, found in the overall analysis.

distances which are analysed through multidimensional scaling (MDS). Because we used the unconstrained pile sort method, each pile sort resulted in a different number of piles and a different number of objects in each pile. In translating the frequencies into distances we gave greater weight to smaller groups than to larger groups. In other words, if two objects were placed in the same large group in one pile sort (e.g. they were two of nine objects in a pile) and in the same small group in another pile sort (e.g. they were two of three objects in a pile) we weighted the smaller group more heavily in calculating the frequency with which these two objects were classified together. When a satisfactory MDS solution was identified the dimension scores of each object were then subjected to a hierarchical cluster analysis in order to produce an easily understandable dendrogram of the relationships between all of the objects.

### *1.2.3 Q-sorts*

The purpose of a Q-sort is to describe the differences in the kinds of claims that different stakeholders make about an issue, in this case fisheries management. Social scientists have a large number of ways to describe this kind of subjectivity. The most well known quantitative approach is the simple interview question where a respondent is asked to rate a statement on some scale from strongly disagree to strongly agree. The intent of the Q-sort is to perform the same kind of measurement, but Q-sorts are a more valid measurement technique for two reasons. The first is that a Q-sort is traditionally done with statements generated by previous qualitative interviews, while survey techniques are traditionally done with statements generated by the researchers initial theories about what is important. Standard surveys are usually used to try to characterise a large population in terms of some fairly simple questions. It is very difficult and likely not cost-effective to do in-depth qualitative interviewing and selection of statements when trying to understand simple questions about a large population. However, it is, in principle, possible to use statements generated by the study population in a standard survey. The other reason the Q-sort is superior is that it does not simply ask the respondent to give his or her opinion of a statement that has been abstracted from the discussion, it forces the respondent to deal with the statement through a comparison with a number of other statements that cover the main points in the discussion. Respondents do not only rate a statement in terms of agreement or disagreement, they must also decide how strongly they agree or disagree with the statement in comparison to these other statements. The forced normal shape of the Q-sort means that the statements that generate the strongest feelings will have the greatest influence on the outcome of the analysis.

These methodological issues are why we could not base the statements directly and exclusively on the candidate indicators. First, management indicators are not usually a pre-existing part of how fishers see the world. We use the statements generated in the in-depth interviews in order to base our research, which is meant to try to understand the fishers' world view, as much as possible within that world view. This is the reason the in-depth interview guidelines themselves are designed to begin with the maps and time lines, so that our categories were not imposed on the fishers' discussion too soon. The majority of the things that fishers find important are not directly related to the indicators, and this fact comes through in these results. As the Q-sort statements have to cover the main points in the overall fisheries management discussion in order to force comparative decisions, the use of the Q-sort to evaluate the candidate indicators must be indirect. A two step process is required in which the use of knowledge by the fishers and other stakeholders is mapped, and then whether and how the indicators fit into that map can be evaluated.

In a Q-sort, a number of statements made in the initial interviews (in this case 20) were selected to represent the range of opinions found in the interviews. The statements are left as close as possible to the original wording. These sets of statements are given to respondents who are asked to order them according to both agreement and importance. After they sort the statements there is a follow up interview asking them their reasons for their various choices. Respondents order the statements following a forced distribution. With twenty statements they give a value of -4 to one statement, -3 to two statements, -2 to two, -1 to three, and 0 to four statements with the positive numbers from 1 to 4 being the mirror image of the negative ones. The statements that the respondents feel the strongest about, whether through agreement or disagreement, end up with the highest absolute values, while the larger group of statements that elicit a less strong reaction cluster around the values of -1, 0 and 1.

These rank orderings are then submitted to a Q factor analysis. Standard or R factor analysis consists of taking a set of correlations between real variables and identifying underlying pseudo-variables called factors in order to illuminate the underlying structure of the data. The point of these factors is that they are independent, i.e. not correlated at all with one another. The basic results of factor analysis are factor "loadings", numbers which indicate the extent to which each real variable is correlated with the factors, and factor "scores" which indicate how a particular respondent ranks on each of the factors. Q factor analysis turns standard R factor analysis on its side: rather than extracting factors from correlations between variables they are extracted from correlations between respondents. Thus the factor loadings apply to each person and the factor scores apply to the "variables", i.e. they apply to the statements that the respondents ordered. The key to understanding how the analysis works is that these factor are linear associations between the matrix variables (e.g. the respondents' answers). In other words, the factors are the product of all the response answers multiplied by a set of weights and added together. The first linear association is calculated and then the variance that that association explains is removed from the matrix and the process is repeated until no linear relationships remain between the variables. This calculating of linear associations can begin, in principle, with any set of weights. We use weights that maximize the amount of variance that is removed by the factor we are calculating. When all the factors have been calculated in this way we have the 'non-rotated' solution. Then we rotate the factors by transforming each one with a single formula, which means that they change their position in relation to each respondent's answers while remaining independent of one another. This formula is chosen to maximize the degree to which the factors illuminate differences between the respondents.

# 2. Results: The Lower Sedone River in Laos

## *2.1 Description of Research Area*

The area of this case-study was the lower part of the Sedone river, a significant tributary to the mid-Mekong river in Southern Laos. Sedone is about 60 km long and joins the Mekong at the provincial capital Pakse. About 35 km upstream, the Selabam hydro power dam constitutes an effective barrier to fish migrations. From Selabam to Pakse there are 15 (named) villages on both sides of the river. The sizes of these range from 80 – 160 households. Most families are engaged in both fisheries and agriculture and often the selling of fish provides supplementary income for the family. The fishing is mainly part-time and is carried out from small boats, mainly with gill-nets in the dry season and long lines and traps in the wet season. The use of cast-nets is also common in the dry season. The important fishes of the Sedone river can be divided into two very different groups: Migratory and non-migratory species. The migratory species come from Mekong and typically enters the river in the beginning of the wet season and presumably disperse in the lower river to spawn. The fisheries are managed by the Provincial Department of agriculture and forestry in cooperation with the Department of Livestock and fisheries. The few regulations (ban on use of poison and explosives) are issued and reinforced by the district management.

## *2.2 The Initial In-depth Interviews*

In Laos, 18 interviews with fishers, two interviews with fish traders, and three interviews with government officers were carried out in February of 2001 in villages along the entire length of the study area. Most of the fishermen we interviewed, told us that the fishery in the Sedone used to be good, but that catches had decreased much during the last few years. A few of them however, stated that there had been no change in the fishery. The other general opinion was that the water level of the Sedone had gone down quite a lot over the last few years. When asked about the reasons for the decreasing catches most fishers mentioned increased fishing effort and extensive use of gill-nets. Many of the fishers had suggestions for regulations of the fishery and several villages had decided to put such regulations into effect (and reinforce them in cooperation with the District authorities). These regulations were primarily aiming at protecting the upstream migrating spawners from being harvested when they move into the small seasonal streams. We also interviewed people working in the fish trade business and we expected them to confirm the fishers' observation of steeply decreasing catch, but this was not the case. The two traders we interviewed agreed that the business went just as always with no shortage of fish.

The general evaluation of the (biological) information provided through the interviews is that it is possible to obtain meaningful information about the fishery and to a certain degree about the environmental state of the river. There are severe limitations in the quality of the information we got about individual fish species, especially because much of the life history of most important species is unknown. The picture is further complicated by the fact that it is very difficult to talk about individual species with local people because many (most!) local names refer to a group of fishes rather than to one particular species. Some fishers were very knowledgeable and others knew very little, but our main problem is that we have no ways of verifying the statements. When most fishermen say that the Pa Jork eat shrimp, worms and frog, because that's what they use for bait, that information can hardly be used to draw conclusions about the fish's diet. Thus, we may get much information, and there may even be a broad local consensus on that information, but that does not mean that it is biologically meaningful information that can be used as basis for management. However, as there will always be a lack of valid biological information to base management decisions upon, local knowledge should be utilised.

Below is a list of possible indicators, whose ability to provide meaningful biological information and be useful from a management perspective, was initially tested through our talks with fishermen in Sedone.

| | | | |
|---|---|---|---|
| Habitat | | *Abundance* | |
| 1) | Water level | 1) | Fish catch |
| 2) | Water quality | 2) | Fish size |
| Effort | | 3) | Species diversity |
| 1) | Number of people fishing | 4) | Algae on rocks. |
| 2) | Amount of fish sold | 5) | Smell of the water. |
| 3) | Number of boats | 6) | Surface activity. |
| | | 7) | Fish-made noise. |
| | | 8) | Fish gathering in deep pools |

In addition a large number of statements were generated and used in the later social evaluation methods.

## 2.3 The Social Evaluation of LEK and the Role of the Indicators

### *2.3.1 Consensus Analysis*

In Laos the Consensus Analysis was carried out twice. The first time was in April of 2001. As this was the first time we used the method we did four days of the field testing using a team than included both biologists and social scientists. A substantial number of statements were rejected as being unclear, the main problem was unclear species names. Some fish species had different local names even in villages within a few kilometres of each other and other local names referred to groups of species rather than to individual species. The April 2001 work finished with carrying out 70 consensus interviews using 27 statements that survived the various changes and tests. In October of 2001 we repeated the consensus interviews in Laos with another set of 24statements. The reason for this repeat testing was to help us evaluate the degree to which we might be getting biassed results because of the idiosyncrasies of particular statements. This retest was not very effective, however, because we had made use of the clearest statements in April and the ones we had left in October were lower quality 'leftovers.' The consensus statements for both April and October 2001 are included as Appendix Two.

The cultural consensus model (Table 2.3.1) does fit fishers observations about the Sedone ecosystem. The second column holds the main result, the ratio of the first and second eigenvalues. If the reported ratio is greater than 10 then the rule of thumb is that the cultural consensus model certainly fits the data, if it is less than three then a cultural consensus model does not fit. The cultural consensus model means that 1) that fishers agree with each other to a very high degree and that 2) there is only one thing that is exerting any significant influence on their responses and we interpret this one thing as being what they actually see in nature. If the model does not apply it means that something else besides a high agreement coming from observations is having some influence on their answers. This may be that different groups are observing different things, (for example, excluding the fishers interviewed in April who reported that they frequently fish in the mainstream Mekong improved the fit of the model) or some other factor is causing systematic bias.

Table 2.3.1: Test of Model Fit for the Consensus Analysis

| Field Trip | Eigenvalue or the first factor | Ratio of first and second eigenvalues | Number of questions | N |
|---|---|---|---|---|
| April | 33.063 | 8.292 | 27 | 70 |
| October | 12.161 | 4.455 | 24 | 34 |
| October | 12.253 | 4.335 | 19 | 34 |

Table 2.3.1 reports the results for the consensus analysis. The 70 interviews from the April fieldwork strongly support the hypothesis that there is a cultural consensus around LEK among fishers on the Sedone River. The two tests from October involve the same set of questions. The difference is that six of these statements were in a new category where we asked about the behaviour of fishers. Four statements, of which one was about fishing behaviour, were not used in the analysis because the interviewers could not be sure that they had been clearly understood. (Including these statements, however, made no difference in the results.) Table 2.3.1 reports the results from both the remaining 24 statements and the 19 remaining statements that dealt only with LEK, excluding those related to fishing behaviour. An important consideration in interpreting Table 2.3.1 is that because the statements were selected from the same set of transcripts, the clearer and more representative statements were selected in April, while those used in October were "leftovers" that had not been chosen for inclusion in April.

A second set of results involves the type of question asked. One important hypothesis is that number of correct answers will be different for different kinds of local knowledge. This is a critical test for helping us to understand the role that local knowledge can be play in management because the proportion of correct answers measures the reliability of local knowledge in the different knowledge categories. We examined three kinds of biological knowledge: knowledge about fish behaviour; knowledge about fish habitat; and knowledge about fish abundance. Two tests are really involved in this. The first test is whether or not there are differences in the number of correct answers for statements that purport to reflect these three theoretical categories of knowledge. This is accomplished by a simple statistical comparison of mean right answers. The other test is if the three theoretical categories are actually meaningful ways to conceptualize local knowledge. This test can only be done by repeating the statistical tests using difference sets of statements that the investigators believe represent the categories. If similar statistical results emerge from these repeated tests then a conclusion that the categories are meaningful and that the statement selected represent these categories is warranted.

| Table 2.3.2: Mean Proportion of Correct Statements by Type of Statement Laos Data from 2001 | | | | |
|---|---|---|---|---|
| | | Abundance | Habitat | Fish Behaviour |
| April | Mean | .61 | .81*** | .82 |
| | N | 70 | 70 | 70 |
| October | Mean | .85 | .67*** | .79*** |
| | | Abundance - Behaviour difference is not significant | | |
| | N | 34 | 34 | 34 |
| Asterisks indicate significant of difference between the indicated mean and the mean to its immediate left. | | | | |

The April results find significant[2] differences between knowledge habitat and abundance and behaviour and abundance, with behaviour have the highest proportion of correct answers highest and abundance the lowest (Table 2.3.2). The October results find significant differences between all three types of statements, but find abundance to have the highest proportion of correct answers, followed by behaviour and habitat. These results do not support the idea that these categories are meaningful predictors of the degree of agreement that will be found among fishers.

A third set of results examines how local knowledge varies between different groups of fishers. One of the products of the consensus model is a set of correct answers with which knowledge of the various respondents can be evaluated. We examined how the proportion of correct answers varied according to when or where the fishers fished, how long they had been fishing, how long they had been fishing in the Sedone, and what kinds of gears they used. The only systematic differences we found were related to the kind of gear used (a pattern which, as reported below, was found in the Viet Nam case as well.) These differences are reported in Tables 2.3.3 and 2.3.4.

[2]The research situation in both Laos and Viet Nam involves extremely tight government control over activities. It was not possible to carry out any kind of randomization procedure, respondents were instead selected by village government officials and interviews took place under government observation. The research itself did not seem to be politically sensitive to these officials, this was merely their standard operating procedure, so we have no reason to believe this introduced a systematic bias. The use of term “significant” should be interpreted merely as a description of the strength of the relationship found among respondents and not as a claim about the general population of fishers.

| Table 2.3.3: Differences in Mean Proportion of Correct Answers by Gear Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fishers has a.. | April | | | October | | | Both | | |
| | Difference | p | N | Difference | p | N | Difference | p | N |
| Trap | +.05 | .09 | 14 | +.05 | .14 | 8 | +.05 | .03 | 22 |
| Gillnet | +.03 | .44 | 64 | +.01 | .75 | 30 | +.02 | .4 | 94 |
| Castnet | +.02 | .31 | 41 | +.04 | .22 | 26 | +.02 | .16 | 67 |
| Longline | +.02 | .19 | 56 | +.01 | .68 | 14 | +.02 | .16 | 70 |
| Total N | | | 70 | | | 34 | | | 104 |

Table 2.3.3 compares the mean proportion of correct answers among fishers who used different gears. Only the fishers who use a trap are found to be significantly different, on average they get a .05 higher proportion of answers correct than do other fishers. The ostensible anomaly that all the gears increase the mean proportion correct at least slightly is explained by Table 2.3.4, which reports the mean proportion of correct answers by the number of different gears used by the fisher. The table shows nearly the same pattern for April data, October data and their combination. There is a sharp increase in mean proportion of correct answers as we move from fishers who use only one gear, to those using two gears, to those using three gears. At the three gear point the increase stops with fishers who use three or four gears getting essentially the same proportion correct, the October data even shows a slight decrease between three and four gears. Clearly experience with different kinds of fishing, rather than simply the number of years or places where they fisher, is what accounts for the extent of the fishers' local ecological knowledge.

| Table 2.3.4: Mean Proportion of Correct Answers by Number of Gear | | | | | |
|---|---|---|---|---|---|
| Fisher has: | One Gear | Two Gears | Three Gears | Four Gears | P/ total N |
| April Proportion Correct | .71 | .75 | .79 | .79 | .07 |
| Number of fishers in category | 8 | 15 | 31 | 15 | 69 |
| October Proportion Correct | .71 | .75 | .81 | .78 | .26 |
| Number of fishers in category | 4 | 13 | 6 | 11 | 34 |
| Combined Proportion Correct | .71 | .75 | .79 | .79 | .01 |
| Number of fishers in category | 12 | 28 | 36 | 26 | 103 |

A fair question then, is whether all the differences in Table 2.3.3 can be attributed to the effect of the number of different gears. In the combined data the correlation between the proportion correct and the number of gears a fisher uses is .25**. When a partial correlation is calculated with the influence of being a trap fish removed this correlation drops to .17. The conclusion is that both the number of gears, and the use of the trap gear, has a weak positive association with the proportion of correct answers.

Table 2.3.5 addresses those statements which are directly related to the candidate indicators. The relevant statements are listed in Appendix Three.

| Table 2.3.5: Proportional Agreement between Respondents and Proportion of Correct Answers for Statements Relevant to Indicators | | | |
|---|---|---|---|
| Types of Indicators | Combined April and October 104 Respondents | | |
| | Proportional Agreement | Proportion Correct | N |
| Water Level | .38 | .69 | 2 |
| Water Quality | .22 | .46 | 4 |
| Access to spawning | .50 | .75 | 8 |
| Number of people fishing | .29 | .65 | 1 |
| Fish catch | .43 | .72 | 4 |
| Fish size | .69 | .84 | 3 |
| Species diversity | .73 | .87 | 4 |

N = the number of relevant statements. Proportional agreement is the proportion of respondents who agreed with one another. It is calculated by subtracting the frequency of one answer from the frequency of the other and dividing this difference by the number of valid responses. 1 indicates perfect agreement between all respondents while 0 indicates an exact 50-50 split.

Table 2.3.5 shows considerable variation in levels of agreement about statements related to indicators. Observations about water quality have very low levels of agreement, reflecting differences in appearance in different parts of the river. Most of the other types of indicators have a proportion of correct answers around .7 while fish size and diversity are both greater than .8. These results suggest that as far as these candidate indicators are concerned greater reliability of responses and agreement between the fishers can be found with general observations about the quality of the catch, i.e. changes in the size of fish being caught and the species make-up of the catch than observations about catch rates. Observations about catch rates, both in general and about specific species likely depend more on fishers' skills and locations that do the size of the fish. The statements about diversity refer to species disappearing entirely, something that would be observed and remarked on the same way along the entire study area.

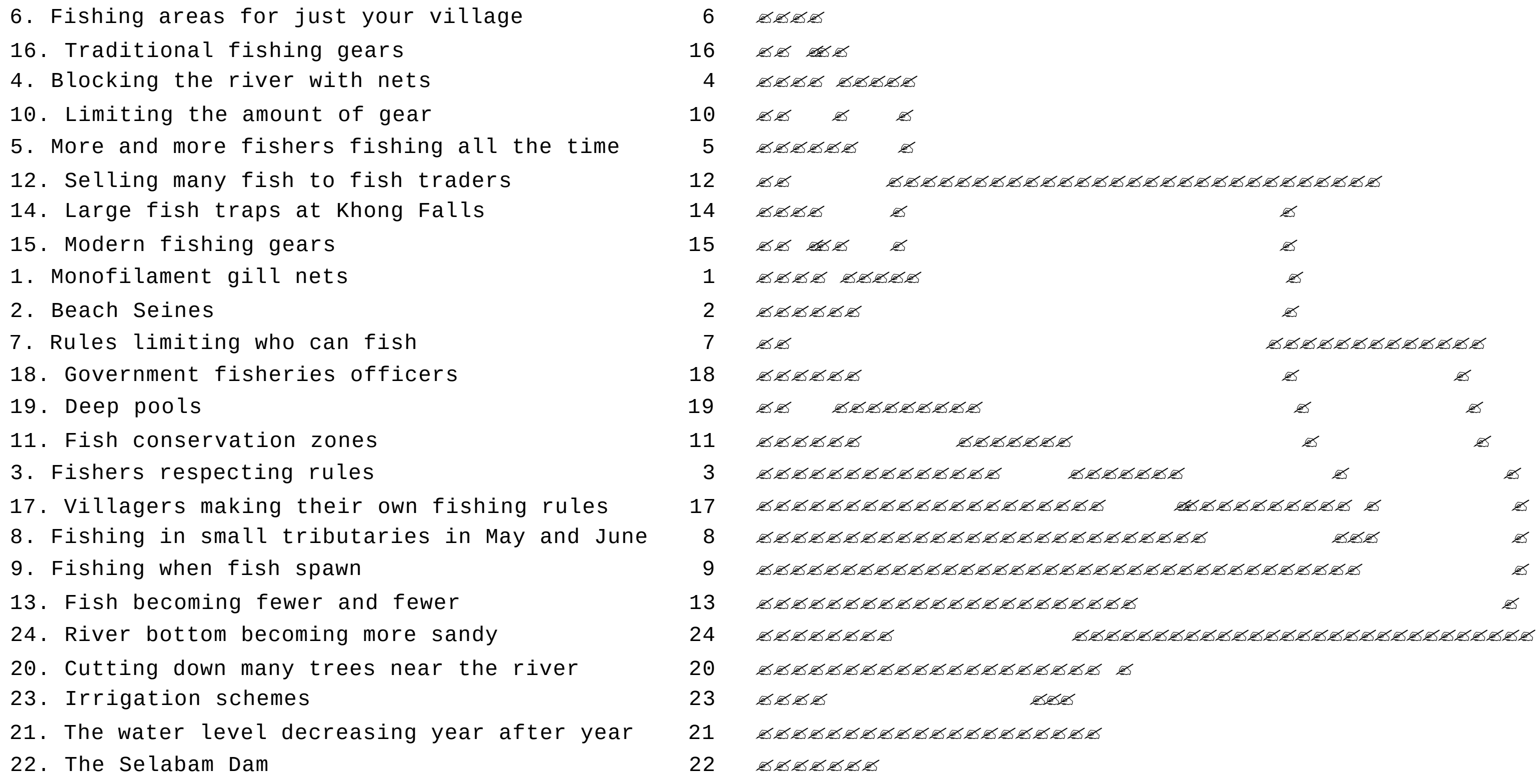
### *2.3.2 The Pile Sorts*

Pile sorts were carried out in the Laos case in October of 2001. In this case, the pile sorts were a second choice. Our original intention was to use Q-sorts because they yield richer data and are easier to interpret. However, Q-sorts require respondents to be able to say whether or not they agree or disagree with a statement. In our field testing we found a number of fishers in Laos would react to the subject of a statement rather than to the whole statement. For example, one fisher was ranking the statement “the irrigation schemes cause the fish catches to decline.” He kept insisting that he did not agree with the statement because he thinks that irrigation schemes are bad for the fish. It was the irrigation schemes that he wanted to agree or disagree with, rather than the statement itself. This seemed an insurmountable problem with any method that involved agreement with statements. So we decided to use pile sorts in this case. All of the pile sorts were done on the following list of objects:

1. Monofilament gill nets
2. Beach Seines
3. Fishers respecting fishing rules
4. Blocking the river mouth with nets
5. More and more fishermen fishing all the time
6. Fishing areas for just your village.
7. Rules limiting who can fish
8. Fishing in small tributaries in May and June
9. Fishing when fish spawn
10. Limiting the amount of gear a fisherman can use
11. Fish conservation zones
12. Selling many fish to fish traders
13. Fish becoming fewer and fewer
14. Large fish traps at Khong Falls
15. Modern fishing gears
16. Traditional fishing gears
17. Villagers making their own fishing rules
18. Government fisheries officers
19. Deep pools
20. Cutting down many many trees near the river
21. The water level decreasing year after
22. The Selabam Dam
23. Irrigation schemes
24. River bottom becoming more sandy

We took twenty four objects mentioned as important by fisheries in the initial interviews and put them on cards. We asked the fishers to sort these cards into groups in any way that they wanted to and then explain to us why they put them the way they did. The first few attempts at this did not work well, fishers found it a bit overwhelming. Some of them managed to do it sensibly and some did not. Then we decided to try doing the sorting with groups of three to four fishers. This worked very well. It also had the very valuable added bonus that we could record their discussions while they were doing the sorts and this gave us 20 minutes or so of fishers’ discourse prompted only by the 24 objects and not by any questions we were using to frame responses. We proceeded to carry out 20 sorting interviews with groups of fishers and 9 with fisheries officers who worked on the Sedone. The 20 fisher pile sorts were analysed through MDS and yielded a four dimension solution with a stress of .10. Stress is a measure of the fit of the solution, the lower the stress the better the fit with the rule of thumb being a minimum stress of .15. The scores for each of the statements on the four dimensions were then used as the basis of a hierarchical cluster analysis that yielded the following dendrogram:

**Figure 2.3.1: Dendrogram of Combined Results of the 20 Fisher Pile Sorts**



## Figure 2.3.2: Dendrogram of Combined Results of the 6 Officer Pile Sorts

| | |
|---|---|
| 3. Fishers respecting fishing rules | 3 |
| 17. Villagers making their own fishing rules | 17 |
| 18. Government fisheries officers | 18 |
| 11. Fish conservation zones | 11 |
| 7. Rules limiting who can fish | 7 |
| 10. Limiting the amount of gear a fisher can use | 10 |
| 6. Fishing areas for just your village | 6 |
| 19. Deep pools | 19 |
| 8. Fishing in small tributaries in May and June | 8 |
| 16. Traditional fishing gears | 16 |
| 9. Fishing when fish spawn | 9 |
| 14. Large fish traps at Khong Falls | 14 |
| 13. Fish becoming fewer and fewer | 13 |
| 1. Monofilament gill nets | 1 |
| 2. Beach Seines | 2 |
| 12. Selling many fish to fish traders | 12 |
| 15. Modern fishing gears | 15 |
| 5. More and more fishers fishing all the time | 5 |
| 4. Blocking the river with nets | 4 |
| 22. The Selabam Dam | 22 |
| 23. Irrigation schemes | 23 |
| 24. River bottom becoming more sandy | 24 |
| 21. The water level decreasing year after year | 21 |
| 20. Cutting down many trees | 20 |

The nine officer sorts were analysed through MDS and yielded a four dimension solution with a stress of .07. The scores for each of the statements on the four dimensions were then used as the basis of a hierarchical cluster analysis that yielded the following dendrogram:

A comparison of the two dendrograms suggests three ways in which the fishers (Figure 2.3.1) and the officers (Figure 2.3.2) differ in their classifications that may be meaningful in understand the different ways they might understand the candidate indicators of ecosystem health.

The first is the classification of statement 13 “the fish becoming fewer and fewer”. The officers place this statement squarely with what they see as destructive fishing practices (Figure 2.3.2). The closest statements are 14 “fish traps at Khong Falls” and 9 “fishing when fish spawn”. After these two the next closest relationship is with a set of statements related to increased fishing pressure and the use of more modern fishing gears ( statements 1, 2, 12, 15 and 5). The fishers, (Figure 2.3.1) on the other hand, classify statement 13 “the fish becoming fewer and fewer” most closely with statement 24 “river bottom becoming more sandy” and then in the next step with four other statements about habitat (statements 20, 23, 21 and 22). This set of habitat statements is itself set distinctly apart from the rest of the statements. The difference is clear, the fishers associate the lost fish abundance primarily with changes in habitat, while the officers associate it primarily with fishing.

The second interesting difference is in the way that statement 19 “deep pools” is classified. One of the central debates in fisheries management in Laos is over the role of deep pools. Deep pools are areas in the river that are deeper than other areas and where fish congregate, particularly in the low water season. At the time of our research there were no FCZs on the Sedone, these were all in the Mekong main stream, mainly to the south of the mouth of the Sedone near the Khong Falls. The equivalent rules on the Sedone are those protecting the small tributaries during the spawning season (statements 8 and 9). The FCZs near the Khong Falls have arisen mainly from an effort at village self-management involving a local NGO. FCZ are the most significant kind of regulation in this area . One reason FCZs are critical in Khong Falls area is that the dry season is the main fishing season and the large fish stay in the deep pools during the dry season. The FCZs are controversial partly because of their origin as a local community / NGO initiative and partly because of disagreement over the importance of non-migratory fish in the Mekong system. Some observers argue that the FCZs are of little importance because they are not effective in the management of migratory fish (Hirsch 2000) while others argue that non-migratory species, as well as species that migrate short distances, are important to the local fishers (Baird 2000). Baird (2000) further argues that the protection of all fish in the dry season when they are the most vulnerable.

In the government officer pile sort (Figure 2.3.2) statement 19 “deep pools” is associated most closely with statement 6 “fishing areas for just your village”, statement 8 “fishing in small tributaries in May and June” and statement 16 “traditional fishing gears.” Statements 6 and 8 are also examples of village level protected areas, which the officers apparently associate with traditional fishing. One step away from these four statements are found more formal management processes and rules. It is here that statement 11 “fish conservation zones” appears. The fishers (Figure 2.3.1) classify the deep pools more directly with the FCZs, rules about fishing access and with “government fisheries officers.” It seems that each group associates the idea of deep pools with the other group.

A third interesting observation is that the fishers (Figure 2.3.1) classify the drivers of effort 5 "more and more fishers fishing all the time" and 12 "selling fish to fish traders" as part of a cluster of close-to-home management measures (statements 6, 16, 4 and 10) before linking them to larger scale and more modern gears (statements 14, 15, 1 and 2) in the next step. The officers (Figure 2.3.2) link these effort statements directly with the larger and more modern gears (statements 1, 2, 15 and 4). This may reflect scale-based perceptions with officers seeing these things as regional system drivers with primarily technological impacts and the fishers seeing them as less abstract, local phenomena.

Another possible reflection of the fishers having a more concrete way of categorizing things is the way that rules are treated. Four of the sorted objects are rules, i.e., statements 6, 7, 10 and 11. The officers place all four of these rules together, with 7,10 and 11 right next to each other and then 6, the only rule that they does not come from the officers, placed on step away with some rule-related attitudes and procedures in between. For the officers rules are, indeed, primarily rules. The fishers, on the other hand, scatter the rules around. None of them are in the same primary group, they are all placed near other objects, i.e., people, gears or activities that the fishers associate with the content of the rule.

## 2.4 Biological Evaluation of the Candidate Indicators in the Field

In the period of October 31- November 3. 2001, the biological evaluation team made eight additional interviews in eight villages along the Sedone River. Of these villages we had visited only one in February. The questions used in these interviews are attached in Appendix Four. In each village we selected the fisherman that was regarded as the most experienced. All the interviews showed clearly that the candidate indicators were poorly perceived by the fishers. It was very difficult to communicate the idea of these causalities or relations between factors to the fisher and answers were mostly unclear. This (expected) problem may be best illustrated by going through the candidates one by one:

### *2.4.1 Habitat*

Water level (Q 1,13,17). Most fishers agreed that dry-season water level of the Xe Don had gone down (50cm – 1m), but two fishers said there had been no change. Most fishers agree that high water gives good catches, and say this is due to high migratory activity during high water. Most also agree that cutting down many trees decrease water level as do irrigation and when asked some say that irrigation is the most important. Two fishers say these things have no effect. Conclusion: In Xe Don, dry season water level is probably decreasing as result of clear cutting and irrigation, but it is not clear if this decrease also leads to a decrease in suitable fish habitats or just changes some species migration patterns. However, changes in dry season water level in Mekong tributaries like the Xe Don seems like good indicators of changes in land use in the drainage.

Water quality: (Q7). Varying answers from "the water has become clearer" to "The water is dirtier now because I saw some foam and some dead fish". Generally there seems to be no problems with water quality and people use it for household and swim in it without problems.

Flooded areas: (Q9). Varying answers from "30% less now than before" to "More areas are now flooded" and many "No change" answers. The year-to-year variation seems to be to large to say anything conclusive about the size of flooded areas.

Access to spawning areas (Q5). This question was only put in the first interviews because it seemed impossible to get answers even after long explanations. There has “always” been people fishing in these streams and there are now restrictions on the fishing making it illegal to block streams with fishing gear. Still most fishers mention the problems with the use of fine meshed gear, intercepting smaller and smaller fish including juveniles.

### *2.4.2. Effort*

Number of people fishing (Q6). All fishers answered this question positively.

Amount of fish sold (Q10). Five fishers said that now less fish was sold than before and the remaining 3 said the opposite.

Number of boats (Q14). One fisher said that in his village all boats were mainly used for fishing whereas all the others said that between 40-60 % of the boats were mainly used for other things. So the number of boats in a village can not directly be used as an indicator of fishing effort.

### *2.4.3. Abundance*

Fish catch (Q2,3). All but one fishers said that catches in both the main river and the tributaries had decreased significantly (from a three- to a tenfold decrease). The fishers who fish both in the main river and in the seasonal streams all said that the decrease was the same both habitats. The one fisher who did not know about changes in catch had only 3 years of experience.

Fish size (Q4). All said that many fish were smaller now, but some were the same. When discussing this it appeared that the small (lateral migrating) species are same size as always, whereas the larger species (that need more years to reach sexual maturity) had decreased much in size. This is what could be expected when traditional gear is replaced by monofilament gill-nets with small mesh size.

Species diversity (Q8). In six of the interviews the fisher could mention 2-5 species that they used to catch but that now had disappeared. One fisher said no change and one said that he did not know.

Algae on rocks as indicator of abundance (Q11). All fishers knew about fish grazing algae of the rocks in the dry season, and could also mention species. None of the fishers could give any clear statements about being able to use the amount of algae as sign of fish abundance. One answered that fish eat some, but the snails eat much more of the algae. Another said that he thought that craps were eating much too.

Smell of the water as indicator of abundance (Q12). Two of the fishers had not noticed that sometimes the water smell of fish. The remaining six had all smelled fish and could also mention species and time of year. It was always in May-June during the spawning of the mentioned species that the smell was noticed. Three fishers said that it used to be more pronounced and one even stated that twenty years ago there was five times as much smell as now.

Surface activity as indicator of fish abundance (Q15). Two fishers gave unclear answers or did not understand the question. All the remaining six said that the amount of surfacing fish was a clear sign of the number of fish (only certain species 5-6 were mentioned) present. All agreed that there was less activity now than before and they were also giving judgements of the size of reduction (10-30% of previous levels now).

Fish-made noise as indicator of abundance (Q16). Most fishers knew about fish that makes noise and were able to mention several species (and even tell how they sound), but it was almost impossible to get clear answers to weather this was a sign of many fish being present. One fisher said that there was much less noise now than before.

Fish gathering in deep pools (Q18). Again most fishers knew about fish that gathers in the pools and they readily mentioned several species. One fisher mentioned one species (pa khee) that stay in the deep pool, but said that other species also go elsewhere. Another fisher thought that most of the fish stay in the deep pool through the dry season, whereas a third fisher said that only 10% stay in the deep pools and the rest leave for the Mekong River.

# 3. Results: The Dam Doi Shrimp Fishery in Viet Nam

## *3.1 Description of the Research Area*

Fisheries in Vietnam are in principle open access fisheries where only a technical approval of a vessel is required to obtain a fishing license. In the LMD region the shrimp fishery is regulated by means of gear restrictions and technical measures. The management measures for shrimp fishery include a ban on using push netters, closed areas and restrictions on minimum mesh size in the trawls and fixed gears. However, in many situations the enforcement is poor and vessels may fish without having a fishing license and illegal gears are still used. The major part of the marine shrimp catches in Vietnam is taken by the otter trawl fleet whereas the contributions from push netters, trammel net and other gear types are insignificant on the national level. In Ca Mau and Bac Lieu that are the focus of the present case study about 1600 otter trawlers with engines of different capacities were licensed by the provinces in 2002.

## *3.2 In-depth Interview*

In Viet Nam, 16 interviews were carried out in March 2002 with fishers in four coastal villages, Ganh Hao, Rach Goc, Bo De and Dat Mui, and with fisheries administrators at the village, district and provincial levels. Based on the 16 in-depth interviews the following were identified as candidates for indicators of ecosystem health for the Dam Doi Shrimp fishery:

| Habitat indicators | Fishery indicators |
|---|---|
| By most important commercial species:<br>* Geographical distribution<br>* Spawning areas<br>* Nursery areas<br>* Bottom matters<br>* Mangrove<br>* Environmental factors (salinity, temperature, wind, turbidity)<br><br>**Biological indicators**<br>* Fecundity<br>* Size at maturity<br>* Seasonal changes in abundance<br>* Implication of specific events (typhoons etc...)<br>* Size distribution by area | * Effort distribution by gear (areas / day / night)<br>* Total effort (total nr of vessels; days / months)<br>* Species distribution in catches<br>* Total catch by fleet<br>* Catch value by trip<br>* Catch value by species<br>* Catch rates (CPUE)<br>* Catch compositions<br>* Species ratios |

## *3.3 The Social Evaluation of LEK and the Role of the Indicators*

### *3.3.1 Consensus Analysis*

In Viet Nam the consensus analysis was carried out in October of 2003. The consensus analysis in the Dam Doi case was divided between the inshore and offshore fishing areas. For both areas 30 simple, factual statements about the shrimp fishery were selected from those made by the fishers in the initial in-depth interviews. Ten of the statements were related to habitat, ten to changes in abundance, and ten to the behaviour of the various species of shrimp. Fifteen statements were deemed to be equally relevant to the two fishing areas and they were shared between the two sets of statements, while 15 statements were unique to each of the sets. We tried as much as possible to match the different statements in terms of subject matter and difficulty, while also trying to remain faithful to what the fishers had actually said in the interviews. This latter goal was accomplished for the most part, though the need for simplicity and clarity was necessarily given the highest priority in wording. In spite of this effort one statement that appeared in both sets and one statement that appeared only in the inshore set were rejected after the interviewers reported that they were not entirely clear to the respondents. This left a total of 28 inshore statement and 29 offshore statements for the analysis. All of the statements were administered in a true false format. Both sets of statements can be found in Appendix Five. The respondents were, of necessity, selected by the People's Committee in each village, this was arranged by the Provincial Fisheries Officer who accompanied us and was usually carried out by the village staff person responsible for the fishing activities. This procedure introduced a bias toward established fishers and fishers who lived near the offices of the People's Committee.

Table 3.3.1 reports the test of fit for the consensus model. The ratio of the first and second eigenvalues for both sets of statements is greater than 3, allowing us to continue the analysis, but they are both considerably less than 10, which implies that the consensus model by no means has a perfect fit with this data.

Table 3.3.1: Test of Model Fit for the Consensus Analysis

| Area | Eigenvalue or the first factor | Ratio of first and second eigenvalues | Number of questions | N |
|---|---|---|---|---|
| Inshore | 15.133 | 6.128 | 28 | 32 |
| Offshore | 10.519 | 4.614 | 29 | 31 |

Table 3.3.2 is a test of our hypothesis that the categories of abundance, habitat and fish behaviour can be used to predict the degree of agreement between fishers. In both of these cases habitat statements have the highest consensus and behaviour statements have the lowest consensus. As this is a different pattern from what was found in the Laos case we must still conclude that these categories cannot be used as a predictor of the degree of agreement.

| Table 3.3.2: Mean Proportion of Correct Statements by Type of Statement | | | | |
|---|---|---|---|---|
| | | Abundance | Habitat | Fish Behaviour |
| Inshore | Mean | .79 | .85 | .71 |
| | N | 32 | 32 | 32 |
| Offshore | Mean | .69 | .81 | .66 |
| | N | 31 | 31 | 31 |
| Combined | Mean | .74 | .83 | .68 |
| | N | 63 | 63 | 63 |
| All differences are statistically significant at <= .06 except that between abundance and behaviour in the offshore area. | | | | |

Tables 3.3.2 and 3.3.3 examine the impact of a fisher's use of different types of gear. The results are similar to what was found in the Laos case. Fishers who use smaller and more traditional gear, in this case the trammel and gill nets (traps in the Laos case) get a significantly, even dramatically, higher proportion of answers correct than do other fishers. Not only does the use of trammel and gill nets increase scores, the use of trawl and bag nets decrease scores.

| Table 3.3.3: Differences in Proportion of Correct Answers by Gear Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fishers has a.. | Offshore | | | Inshore | | | Both | | |
| | Difference | p | N | Difference | p | N | Difference | p | N |
| Trawl Net | -.12 | .00 | 22 | -.16 | .01 | 27 | -.06 | .00 | 49 |
| Push Net | -.07 | .32 | 3 | -.06 | .32 | 7 | -.05 | .33 | 10 |
| Trammel Net | -- | | 0 | +.13 | .04 | 6 | +.15 | .00 | 6 |
| Bag Net | -.02 | .61 | 14 | -.10 | .16 | 5 | -.07 | .06 | 19 |
| Gillnet Net | +.12 | .02 | 5 | +.08 | .18 | 15 | +.11 | .00 | 20 |

Another influence on the proportion correct is that being from an inshore area raises the proportion of correct answers by .07** . This result is conflated with the influence of using small gears reported in Table 3.3.3, because the smaller gears tend to be used in the inshore area (Table 3.3.4).

| Table 3.3.4: Use of Smaller Gears by Fishing Area - Percentages | | | |
|---|---|---|---|
| | Fisher fishes offshore | Fisher fishes inshore | N |
| Fisher does not use a gill or trammel net | 84 | 47 | 41 |
| Fisher does use a gill or trammel net | 16 | 53 | 22 |
| N | 31 | 32 | 63 |

Table 3.3.5 examines these conflated influences while, at the same time, further clarifying the impact of gear use. Table 3.3.5 investigates the influence of using only smaller gears (trammel or gill nets) or using only larger gears (push, trawl and bag nets) rather than the influence of simply using those gears among others. A dummy regression analysis was also used as a way of controlling for the effect of a fisher fishing in the inshore area. Most of this effect is accounted for by the increased prevalence of the smaller gears (Table 3.3.4). The main influence on the fishers level of LEK is from the kinds of gears they use.

| Table 3.3.5: Dummy Regression on Proportion of Correct Answers | | | |
|---|---|---|---|
| Variable | B | p | N |
| Constant B = mean proportion correct for mixed gear, offshore fishers | 0.79 | 0 | |
| B = change in mean proportion correct when fishers only use smaller gear | 0.1 | .09 | 5 |
| B = change in mean proportion correct when fishers only use bigger gear | -.09 | .01 | 41 |
| B = change in mean proportion correct for inshore fishers | .03 | .3 | 32 |
| N = 63 R square = .28 | | | |

Several possible interpretations of these results present themselves. More knowledgeable fishers could be choosing to use the smaller gears, the use of the smaller gear may require a greater level of LEK, or older and more experienced fishers may be the ones who use the smaller gears. The last interpretation is not supported by the data as neither the numbers of years a fisher has fished nor the number of years the fisher has fished in this area have any influence on their proportion of correct answers. This may, however, be an artifact of our decision to ask the People's Committees to find respondents who were more experienced fishers. We felt that his was necessary in order to get a fair picture of the LEK situation in Dam Doi. As a result, however, it was not possible to see the influence of experience on LEK at the lower end of the experience variable. Of the first two possible explanations the second is likely the stronger of the two as more knowledgeable fishers, given the option, would likely select the larger and more profitable gears. Those who use the smaller gears likely do so because their capital resources are limited, rather than because they have a greater knowledge of the fishery and its environment.

Finally, in spite of the fact that the selection of consensus statements was constrained by the need to use things that the fishers actually told us in interviews, and fishers rarely speak directly in terms of indicators, a number of the statements are at least indirectly related to the candidate indicators. This makes possible an initial assessment of how well fishers agree about observations related to the indicators. The relevant statements are listed in Appendix Six.

Table 3.3.6: Proportional Agreement between Respondents and Proportion of Correct Answers for Statements Relevant to Indicators

| Types of Indicators | Offshore 31 Respondents | | | Inshore 32 Respondents | | |
|---|---|---|---|---|---|---|
| | Proportional Agreement | Proportion Correct | N | Proportional Agreement | Proportion Correct | N |
| Changes in the geographical distribution of shrimp species | .52 | .76 | 5 | .71 | .87 | 3 |
| Size of the nursery areas (existence of specific areas for each species) | 1 | 1 | 1 | .97 | .97 | 1 |
| Changes in Mangrove cover (value of mangrove for shrimp) | | | | .50 | .74 | 1 |
| Temperature | .53 | .74 | 2 | | | |
| Wind | .55 | .55 | 1 | .97 | 1 | 1 |
| Turbidity (behaviour of shrimp in respect to turbidity) | .61 | .81 | 1 | | | |
| Salinity | .87 | .76 | 2 | .90 | .97 | 2 |
| Fecundity | .29 | .65 | 1 | .29 | .66 | 2 |
| Size distribution by area | .02 | .48 | 2 | .36 | .69 | 3 |
| Catch rates (CPUE) | .38 | .68 | 6 | .64 | .83 | 5 |
| Catch compositions | .36 | .67 | 3 | .47 | .73 | 3 |

N = the number of relevant statements. Proportional agreement is the average proportion of the difference between the frequency of the two possible answers on statements relevant to the indicator. 1 indicates perfect agreement between all respondents while 0 indicates an exact 50-50 split between respondents.

Table 3.3.6 indicates that there is a great deal of difference between the candidate indicators in terms of the reliability of the LEK. Only observations of salinity and the size of nursery areas indicate a fairly high proportional agreement, while most of the other indicators are really quite low. It should be born in mind that these are levels of agreement about specific statements that have their own level of difficulty apart from the general subject of the types of indicators, especially in regard to those indicators that only had one or two related statements. The relative lack of agreement between the offshore fishers on catch rates and catch compositions, however, is particularly striking as both represent an average of four different related statements. Also striking is the difference between the inshore and offshore fishers on these two types, as well as several other types, of indicators.

Table 3.3.7 further explores the distribution of knowledge by repeating the analysis in Table 3.3.6 separately for respondents who use some small gear (a trammel or gill net) and respondents that use only larger gear (trawl, push or bag nets). Table 3.3.7 shows that there are differences in levels of agreement about statements relevant to the candidate indicators. For the inshore area, respondents who use small gears exhibit a higher level of agreement among themselves than do respondents who only use larger gears. Two of these differences are particularly large. Changes in mangrove cover has a difference of .62 and fecundity has a difference of .40. In the case of mangrove cover, agreement among the small gear about the statement “If shrimp live in the root of the mangrove, they will grow faster” was much higher among the groups that uses small gear, 15 of them agreed and two of them disagreed. Among respondents who only used large gear eight of them agreed and six of them disagreed, with one respondent missing. In the case of fecundity, two statements are involved. The statement “Bac shrimp has eggs from May to August” was agreed with once again by 15 small gear users and disagreed with by only two, while among those who only use large gear eight respondents agreed while seven disagreed. For the statement only prawns in fresh water have visible eggs” the results were closer. Among small gear users ten agreed and seven disagreed while among those who only use large gear, eight agreed and seven disagreed. In all, for the inshore area Table 3.3.7 indicates substantial differences between the two groups for only two of the nine indicators examined.

The results for those fishers who fish offshore are more mixed (Table 3.3.7). For at least one of the indicators, salinity, the large gear users were in substantially greater agreement. Two statements are related to the salinity indicator. For the first one “the salinity of sea water is highest in August and lowest in March” 24 of the 26 large gear respondents disagreed (it is, in fact, a negated statement, see the discussion of consensus analysis in the methods section) while two out of the five small gear users disagreed. For the second statement “In nature, shrimp have ability to tolerate large changes in salinity” all respondents agreed, with one missing. The largest difference is for the turbidity indicator, and is once again in the direction of the small gear users. In this case all five of the respondents who used small gears disagreed with the statement “all shrimp like to stay in transparent water” while six of the 26 respondents who used only large gear agreed with this statement. In all, for the offshore area, Table 3.3.7 indicates substantial differences between level of agreement for seven of the ten indicators examined.

Table 3.3.7: Proportional Agreement between Respondents for Statements Relevant to Indicators for Users of Smaller Gear

| Types of Indicators | Offshore | | | Inshore | | |
|---|---|---|---|---|---|---|
| | Use Small Gear<br>5 Respondents | Use Only Big Gear<br>26 Respondents | Difference | Use Small Gear<br>17 Respondents | Use Only Big Gear<br>15 Respondents | Difference |
| Changes in the geographical distribution of shrimp species | 0.84 | 0.46 | 0.38 | 0.73 | 0.64 | 0.09 |
| Size of the nursery areas (existence of specific areas for each species) | 1 | 1 | 0 | 1 | 0.86 | 0.14 |
| Changes in Mangrove cover (value of mangrove for shrimp) | | | | 0.76 | 0.14 | 0.62 |
| Temperature | 0.8 | 0.48 | 0.32 | | | |
| Wind | 0.8 | 0.5 | 0.3 | 1 | 0.87 | 0.13 |
| Turbidity (behaviour of shrimp in respect to turbidity) | 1 | 0.54 | 0.46 | | | |
| Salinity | 0.6 | 0.92 | -0.32 | 0.94 | 0.8 | 0.14 |
| Fecundity | 0.2 | 0.31 | -0.11 | 0.47 | 0.07 | 0.4 |
| Size distribution by area | 0.5 | 0.12 | 0.38 | 0.37 | 0.31 | 0.06 |
| Catch rates (CPUE) | 0.72 | 0.32 | 0.4 | 0.72 | 0.60 | 0.12 |
| Catch composition | 0.70 | 0.35 | 0.35 | 0.57 | 0.56 | 0.01 |

### *3.3.2 Q-sort*

Q-sort interviews were administered to 34 people: six inshore and six offshore fishers; four Provincial level fisheries officers; four village fisheries staff members; five members of village People's Committees who were responsible for fisheries in their village; two university biologists; three shrimp aquaculture farmers (two of whom were removed from the analysis because of interviewer errors); a village shrimp dealer; and, the manager of a large, export-oriented shrimp processing company. The Q-sort statements are included as Appendix Seven.

Table 3.3.8 reports the most basic result, even before the data is subjected to factor analysis. The order of the statements should be considered with the variances, which indicate the relative degree of controversy around the statement. As is often the case, overfishing is the most controversial issue, with a mean very close to the centre of the rankings and a variance that indicates that various respondents placed it all over the rankings. Statements that can be related to indicators were almost all ranked in the slightly negative middle. Respondents do not care very much about the idea of an indicator. They also do not feel very strongly about water balloons. Floating 'water balloons' were suggested by two respondents in our initial interviews as something that can be taken as an indicator of a good shrimp catch. This idea was new to the local scientists and they were mainly sceptical, we also soon discovered that many other fishers were also very sceptical about this observation. The idea that biodiversity in the shrimp catch is not important was ranked fairly consistently in the low negative area. The sentiment that only amount of shrimp, and not the differences in kind, is important was only stated by shrimp farmers. It is also informative that the statement about the importance of loss of mangrove cover for the natural (as opposed to aquaculture) shrimp was ranked quite low by the respondents.

| Table 3.3.8: Q-sort Statements Ordered by Mean Ranking among All Respondents | | |
|---|---|---|
| | Mean | Variance |
| Shrimp production has reduced much in near shore area, because there are so many activities such as trawl net and push net. | 1.83 | 3.87 |
| **It would be good if DOFI did not allow the catching of baby shrimp in the inshore area.** | 1.63 | 4.1 |
| There are no methods suitable for preventing shrimp disease yet. | 0.93 | 4.133 |
| The yield of shrimp has dropped down because small boats go fishing inshore. | 0.87 | 4.05 |
| **It would be good if DOFI did not allow the fishing of shrimp brood stock in the spawning season.** | 0.83 | 3.11 |
| I think that government needs to have regulations about mesh size for each fishing ground. | 0.57 | 2.88 |
| Overfishing has reduced shrimp production | 0.53 | 5.499 |
| I think that government needs to have regulations about mesh net for each kind of boat. | 0.27 | 4.62 |
| The yield of shrimp has dropped down due to so many fishing boats. | 0.23 | 3.91 |
| Polluted water has caused dead shrimp. | 0.20 | 3.06 |
| The main purpose of integrated mangrove and aquaculture model is to help every people to recognize the role of the mangrove fore. | -0.13 | 2.95 |
| **You cannot predict the yield of shrimp next year from the yield this year.** | -0.37 | 3.48 |
| The main purpose of integrated mangrove and aquaculture model is to develop aquaculture. | -0.43 | 3.84 |
| **Many water balloons are a sign that shrimp production will be high.** | -0.50 | 3.98 |
| The yield of shrimp has reduced year by year because of new fishing technology | -0.93 | 4.48 |
| **No indicator can show what the production of shrimp will be next year.** | -0.93 | 3.10 |
| Aquaculture has been bad for natural shrimp. | -1.00 | 3.45 |
| **The number of different shrimp species is not important** | -1.10 | 1.54 |
| **There are fewer natural shrimp due to loss of land with mangrove forest.** | -1.20 | 3.96 |
| The lower yield of shrimp is due to heavy rain and storm. | -1.30 | 5.73 |
| Bolded statements are statements directly relevant to possible indicators or indicator management in general | | |

Table 3.3.9 focuses on eight statements where statistically significant differences ($p < .2$) were found between the main stakeholder groups. These indicate areas where systematic disagreement will be found in relation to management issues. The results reflect several differences in perceptions that would be expected. One example is people related to offshore fishing being quicker to blame smaller, inshore boats for the drop in shrimp yield, though the degree to which the professionals take the offshore side is interesting. Another is that offshore people, who are much less involved in aquaculture, see the main purpose of the governments mangrove management efforts (The Integrated Mangrove and Aquaculture Model) as the protection of mangroves while the inshore people tend to see it more as about

the development of aquaculture and are more neutral about its conservation role. The statement that directly criticizes aquaculture for damaging the natural (i.e. non-aquaculture) shrimp resource is strongly rejected by the governments of the inshore villages, somewhat less strongly by the professionals, and the other stakeholders are more neutral. Finally, non-fishers are much more likely to reject weather as an explanation for fishing results than are fishers, although none of the groups gave this an average positive rating. Less obvious, and perhaps more interestingly, local government people want mesh regulations to attach to boats, while the other groups are fairly neutral on this issue. The local government also thinks that pollution is a more important issue that the fishers, particularly offshore fishers, do.

Table 3.3.9: Mean Scores for Statements
with Systematic Differences Among Stakeholders

| | Professionals | Inshore Government | Offshore Government | Inshore Fishers | Offshore Fishers |
|---|---|---|---|---|---|
| There are no methods suitable for preventing shrimp disease yet | -0.2 | 1.67 | 1.67 | -0.5 | 1.67 |
| The yield of shrimp has dropped down because small boats go fishing inshore. | 2.4 | -0.33 | 1.83 | 0.17 | 0.85 |
| I think that government needs to have regulations about mesh net for each kind of boat. | -1 | 1.83 | 1.67 | 0.5 | -0.67 |
| Polluted water has caused dead shrimp. | 0.5 | 1.4 | 1 | -0.5 | -1.33 |
| The main purpose of the Integrated Mangrove and Aquaculture Model is to help every people to recognize the role of the mangrove forest. | -0.6 | 0 | 2.33 | -0.33 | 2.17 |
| **You cannot base on the yield this year to predict the yield of shrimp next year.** | -1.4 | -1 | -2 | -0.33 | 2.17 |
| Aquaculture has been bad for natural shrimp . | -1.4 | -2.67 | -0.33 | 0.5 | -0.83 |
| The lower yield of shrimp is due to heavy rain and storm. | -2.8 | -1.5 | -3.67 | -0.83 | -0.17 |

The professionals category includes both Provincial Fisheries Officers and biologists. The inshore and offshore government categories are the village governments and consists of both members of the People's Committees and their staff members who are responsible for fishing.

Figure 3.3.1 reports the results of the Q-sort factor analysis for the 18 non-fisher respondents. Each box represents one factor. The percentage reported in each box is the percentage of the overall variance accounted for by the rotated factor. The percentage in parentheses in the first factor is the percentage that that factor accounted for in the non-rotated solution (see methods section above for an explanation of Q factor analysis). The remainder of the box describes the content of the factor. In other words, it reports the content of the four-six statements with the most extreme positive or negative scores on that factor. In the non-fisher results, (Figure

3.3.1) each of the stakeholder groups has a factor that is closely associated with their group, meaning that this group's scores on that factor are significantly different from the scores of other groups. The red dashed lines indicate significant disagreement with the factor. The large amount of variance explained by the non-rotated first factor (35%) especially in comparison with the second factor (13%) indicates that the first factor represents a fairly dominant discourse with considerably more support from stakeholders than competing discourses. The village level fisheries staff, however, oppose this dominant discourse. They are much less concerned with both fishing inshore and with catching baby shrimp inshore, while they are much more concerned with the problem of finding solutions to shrimp diseases.

Other points of disagreement can be discerned where positive and negative arrows connect with the same box. For factor three the inshore villagers, in this case meaning the People's Committee members and their fisheries staff, want more mesh size regulations on both boats and fishing grounds. They also resist the idea that a loss of mangrove forest area hurts the production of natural shrimp, in fact one respondent considered too much mangrove to be detrimental to shrimp production and felt that mangroves and shrimp should be kept separate. However, they also feel strongly that the main purpose of the Integrated Mangrove and Aquaculture Model is to develop the mangroves, not specifically to aquaculture. The professionals, on the other hand, while they agree that aquaculture is not detrimental to the natural shrimp, are neutral about both mesh size and the role of the Integrated Mangrove and Aquaculture Model. On factor three both the inshore government staff, with the addition of the offshore People's Committee members are positive while the shrimp dealers are negative. This stems from the first group having a much stronger negative assessment than the dealers of the idea that new technology undermines sustainability while having a much more positive assessment of the idea that overfishing is to blame for the drop in shrimp catches. Finally, there is disagreement about factor five. People working in the offshore villages disagree with the shrimp farmer. The major points of disagreement are that the shrimp farmer does not believe it is important to have regulations about mesh net for each kind of boat, while the offshore village government people think that this is important, and the difference is especially strong where the shrimp farmer strongly disagrees that the main purpose of the Integrated Mangrove and Aquaculture Model is to help every people to recognize the role of the mangrove forest, while the offshore people strongly agree with this statement.

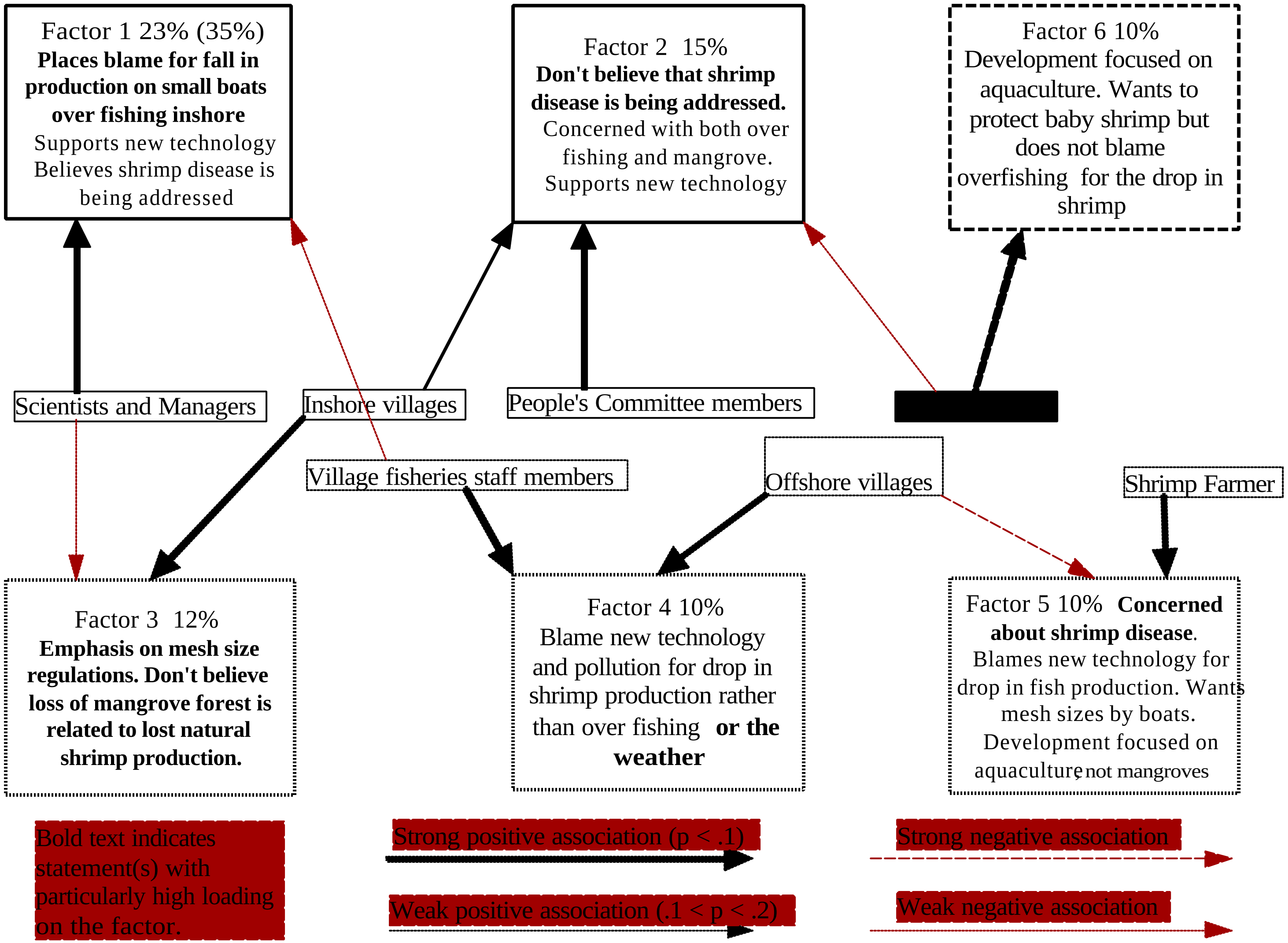



Figure 3.3.1: Results of the Q-sort Factor Analysis among Non-Fishers

Results of the Q-sort among the 12 fishers are reported in Figure 3.3.2. This Q-sort does not show one dominant discourse the way the non-fisher Q-sort does. The variance explained by the first factor in the non-rotated solution is 24%, while that of the second factor is only a little less at 18%. Nor does this Q-sort reveal as many areas of direct disagreement as the non-fisher Q-sort does. What is interesting here is the different groups that emerged. Ecological differences would lead us to expect that there would be similarities of opinion among the inshore and among the offshore fishers, and differences between the two groups. The results of the consensus analysis would also suggest the difference that we do find between fishers using smaller (and hence more different types of) gear and those using only the large scale gear. The category of fishers with more boats is more unexpected, and it is interesting this indicator of wealth should correlate with factor one. Only two fishers have more than one boat, one inshore fisher has two and one offshore fisher has four. These two respondents agree with each other to a remarkable degree, scoring 10 of the 20 statements exactly the same way. Finally, a correlation of .61 exists between the proportion of correct answers in the consensus analysis and factor five. In the consensus analysis this variable was associated with the use of trammel and gill nets, a group that disagrees with factor four but which has not significant relationship to factor five. The bridge between the two is the number of gear, which has a strong negative correlation with factor four and positive correlation with factor five.

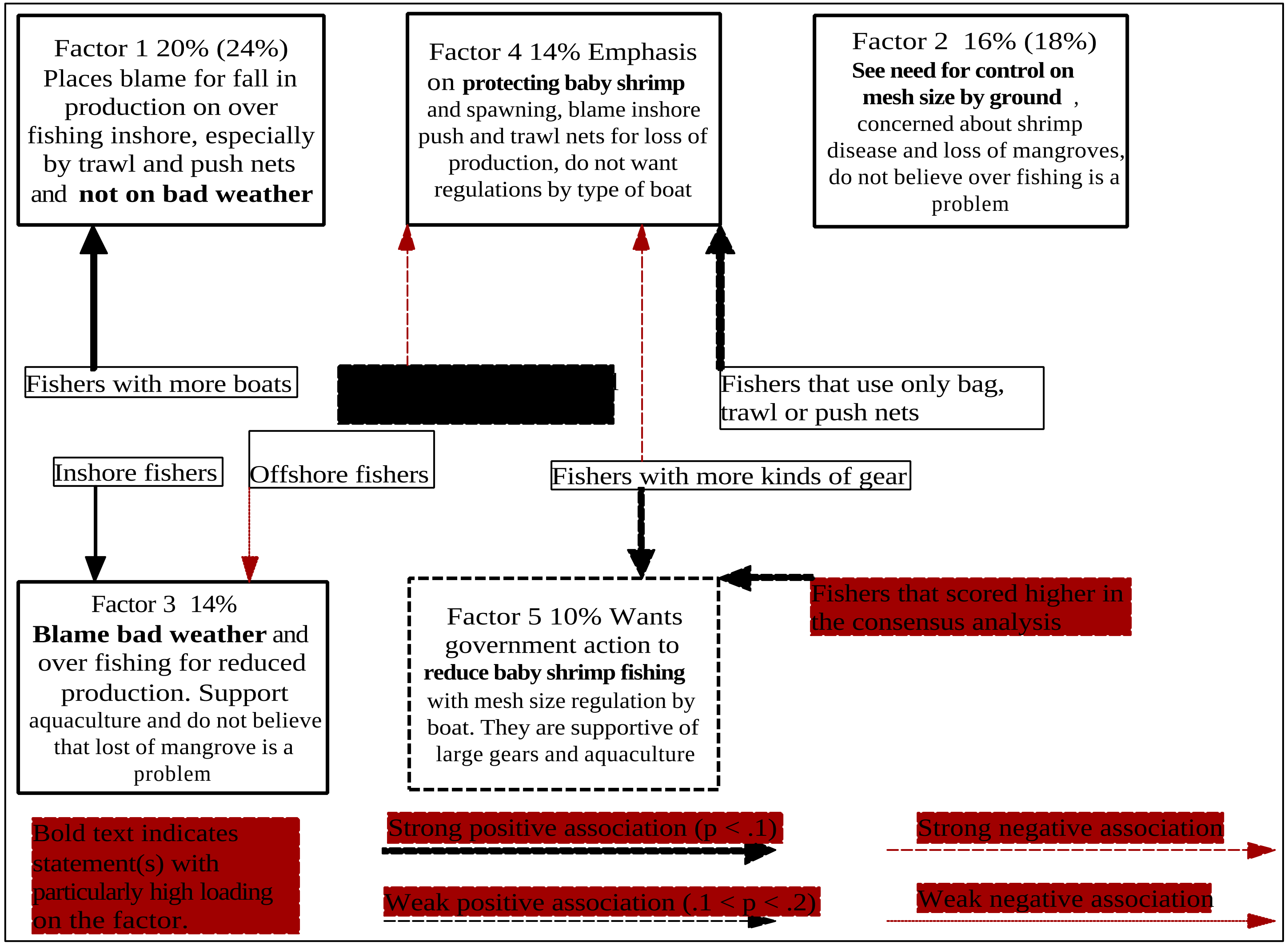



Figure 3.3.2: Results of the Q-sort among Fishers

The disagreement between the inshore and offshore fishers on factor three is mainly about two statements. The inshore fishers rate statement six “there are fewer natural shrimp due to loss of land with mangrove forest” much lower than did the offshore fishers, who rated the statement around 0, indicating disinterest. For statement eight, “You cannot base on the yield this year to predict the yield of shrimp next year”, however, the inshore fishers rated this statement slightly negative while the offshore fishers gave it a quite high mean rating of 2.17. The differences over the first statement, as discussed above, would be a function of the proximity of inshore fishers to the mangrove forest that is being converted to shrimp farming, proximity that would at least lead them to identify with their neighbours who are farming and might lead to even more direct benefits. The differences over the ability to predict yields may possibly stem from the ocean fishers experiencing greater and more unpredictable changes in their catch.

The disagreement between the big gear fishers and the small gear fishers on factor three is mainly about statement 14 “ I think that government needs to have regulations about mesh net for each kind of boat”. Fishers who use only larger gear, i.e. push, trawl and bag nets, rated this statement -1.29, almost three steps below those who used some small gear with an average rating of 1.5.Trammel nets are frowned upon by the government and fishers that use them would likely prefer being assigned an appropriate mesh size to being banned all together. The number of gears fishers used was also positively correlated with statement 14 (.60). In addition it was correlated negatively with (-.51) with statement 20 “There are no methods suitable for preventing shrimp disease yet”. Finally, the fishers with higher scores from the consensus analysis also correlated most strongly (.57*) with statement 14 among the statements characterising factor five.

## 3.4 Biological Evaluation of the Candidate Indicators

### 3.4.1 Introduction

In order to identify candidate indicators of ecosystem health for the Dam Doi shrimp fishery, 16 open ended interviews were carried out with stakeholders from four coastal villages in Ca Mau (Ganh Hao, Rach Goc, Bo De and Dat Mui) and with fisheries administrators at the village district and provincial levels. These in dept interviews resulted in a list of 45 statements, of which 15 were common for inshore and offshore stakeholders as indicated in the text table below.

| Statement | | Percent that agree with statement | |
|---|---|---|---|
| | | Offshore | Inshore |
| 1 | Offshore shrimp species is to stay offshore their whole lives and inshore shrimp species live in inshore their whole lives | 48 | 56 |
| 2 | Shrimp catch composition has not changed | 58 | 69 |
| 3 | Off: Rainfall is not effective to shrimp yield when catch offshore<br>In: If shrimp lives in root of the mangrove,they will grow faster. | 87 | 72 |
| 4 | Only prawn in fresh water has visible eggs. | 36 | 56 |
| 5 | The yield of shrimp has decreased every year | 87 | 94 |
| 6 | Off: All shrimp like to stay in transparent water<br>In:. If the current is stronger the bottom becomes muddier, but a weak current will make the bottom sandier. | 19 | 22 |
| 7 | Shrimp will move to shallow places when they become adult | 48 | 53 |
| 8 | The yield of shrimp reduced suddenly last year | 61 | 53 |
| 9 | Off: The water temperature is gradually increasing from the coastline to offshore in the dried season<br>In: The water balloon can be seen from June to August | 35 | 69 |
| 10 | Sac shrimp stay offshore, from December to January | 55 | 81 |
| 11 | The yield of some species has increased while the yield of others has reduced. | 55 | 47 |
| 12 | Off: Normally, water temperature is low from November till January then it starts to increased to May<br>In: Fishing ground has been changed in rainy season from place to place due to high water turbidity | 87 | 94 |
| 13 | Off: Shrimp breed in the off shore<br>In: Shrimp breed in the shallow places | 48 | 60 |
| 14 | Since 1986, the shrimp yield has reduced rapidly | 77 | 81 |
| 15 | A North wind means we will catch fewer shrimp | 77 | 97 |
| 16 | Off: In south wind season shrimp come to stay in deep places<br>In: Bac has eggs from May to August | 77 | 72 |
| 17 | Off: Gay shrimp became few but now there are many more<br>In: The gay shrimp had a high yield in the past , but it is much less at present | 55 | 94 |
| 18 | Turbid water has a higher yields than transparent water | 61 | 63 |
| 19 | Off: Large, adult shrimp stay in the offshore areas.<br>In: When wind from the sea brings up water, shrimp in the ponds will move to the river | 87 | 91 |
| 20 | Off: The Gay shrimp became very few about 4-5 years ago.<br>In: The The shrimp became very few about 4-5 years ago. | 65 | 94 |
| 21 | Shrimp live in the mud bottom have low value but high yield | 81 | 78 |
| 22 | Off: Su shrimp brood stock live in shallow water.<br>In: Dat shrimp is much more in shallow water | 7 | 100 |
| 23 | Off: Very few sat shrimp are caught.<br>In: Very few giang shrimp are caught | 81 | 68 |
| 24 | Each different species will have different areas of spawning ground. | 100 | 93 |
| 25 | Off: Chi bong shrimp stay in inshore, shallow places.<br>In: Chi shrimp is caught in shallow water | 68 | 28 |
| 26 | Off: In the three recent years, the yield of Giang shrimp has reduced more than the others<br>In: In the three recent years, the yield of Gay shrimp has reduced more than the others | 87 | 97 |
| 27 | The salinity of sea water is highest in August and lowest in March. | 13 | 13 |
| 28 | Off: Gay shrimp often concentrate in depth water levels whole year<br>In: Giang shrimp is caught in deep places | 94 | 31 |
| 29 | Off: I hardly catch Su shrimp<br>In: The natural shrimp decrease year by year | 36 | 94 |
| 30 | In the nature, species have ability to tolerate large exchange salinity. | 97 | 100 |

The 45 statements were divided into three subgroups relating to shrimp distribution and migration patterns (statements 1, 4, 7, 10, 13, 16, 19, 22, 25,28) habitat factors and preferences (statements 3, 6, 9, 12, 15, 18, 21, 24, 27, 30) and abundance (statements 2, 5, 8, 11, 14, 17, 29, 23, 26, 29) respectively and used for a consensus analysis among a larger number of stake holders.

For each sub-group of statements the consensus analysis estimated the level of agreement within and between the different stake holder groups.

The objective of the present analysis is to evaluate the consistency between the perceptions of the two stakeholder groups and the scientific (biological) information available for each statement with particular focus on the abundance statements.

For the present analysis data from various sources were made available:
1. Enumerator catch and effort data covering the period 1996-2002
2. Survey data providing catch rates and abundance estimates from 4 trawl surveys partly covering the period 1975-2001
3. Research project data providing length distributions of shrimp species groups
4. Official catch statistics and fleet information from the fishery department on the provincial level.

Scientific information about shrimp distribution and migration pattern and about habitat factors and preferences were not included in the available data. Therefore these statements are only commented on a general level based on literature. A more thorough discussion of ecological aspects of shrimps in the LMD is provided by Moser and Macintosh (REF).

The abundance statements are addressed through analysis of catch statistics. In particular, the enumerator database was applied to verify statements addressing changes in catch rates and catch composition.

### *3.4.2 Shrimp resource*

The resources of shrimp in Vietnam are characterised by a high number of species (about 225) belonging to 68 genera of 21 different families. The most important shrimp family for the commercial fishery is Panaeidae with 75 species and 3 genera.

As discussed by Moser and Macintosh (REF) the lifecycle of the penaeid shrimp have several features in common. In the LMD region large juvenile and adult shrimp can be found close to the shore or inside the river and tidal channels. They are generalists and feed opportunistically on organisms living in the bottom sediment like bacteria, algae, meiofauna and small macrofauna.

As the nursery habitats are all found in estuarine environments the majority of panaid shrimp are dependant on contact with estuarine environment in order to complete their life cycle. As the shrimp grow larger specimens tends to migrate further offshore.

The distribution of panaeid shrimp might be based on environmental factors such as sediment, salinity, transparency of the water etc. as follows:

A. Estuarine group:
This group include species with larvae and fry stages adapted to sub-tide areas in estuaries or near estuaries. According to their halophylic preferences species of this group can be divided into sub-groups as indicated in text table 3.4.3 and below:

- Euryhaline sub group adapted to low water transparency and large fluctuation of salinity. Representatives: *Metapenaeus ensis* and *M. monoceros*.
- Oligohaline sub-group: adapted to estuaries with low amplitude of salinity. At larvae and juvenile stages these species live in or near estuaries but in their adult stages they are adapted to areas with high and stable salinity. Representatives: *Penaeus merguensis, P.*

*indicus, P. penicillataus, P. orientalis, Parapenaeopsis hardwikii, P. sculptilis, P. gracillima, Metapenaeus affinis, M. joyneri, M. breviscornis, M. tenuipes, M. malaccaensis, M. buckenroadi*

B. Island and offshore group:
Whereas the juvenile stages of this group are found in or near estuaries, the adults are adapted to offshore areas with mud or mud-sand sediments in bays or pools having high and stable salinity and high transparency of waters. Typical for this group are: *Penaeus semisulcatus, P. monodon, P. japonicus, P. teraoi, P. plebojus, P. canaliculatus, P. longistylus, Parapenaeus longipes, P. fissarus*.

C. Rock sediments – sponge group
This group are found in regions with numerous pebbles, shells, branch corals and sponges and stable high salinities and high water transparency. Of the panaeids only *Panaeus latisulcatus* are included in this group.

### *3.4.3 Shrimp fishery*

Fisheries in Vietnam are in principle open access fisheries where only a technical approval of a vessel is required to obtain a fishing licence. In the LMD region the shrimp fishery is regulated by means of gear restrictions and technical measures. The management measures for shrimp fishery include a ban on using push nets, closed areas and restrictions on minimum mesh size in the trawls and fixed gears. However, in many situations the enforcement is poor and vessels may fish without having a fishing licence and illegal gears (e.g. push nets) are still in use (see Zwieten and Dang Van Thi (2002) for a thorough discussion of the fisheries management system in Vietnam).

The major part of the marine shrimp catches in Vietnam is taken by the otter trawl fleet whereas the contributions from push netters, trammel nets and other gear types are insignificant on the national level. In Ca Mau and Bac Lieu that are the focus of the present case study about 1600 otter trawlers with engines of different capacities were licensed by the provinces in 2002 as indicated in table 3.4.1.

Table 3.4.1: Ca Mau Fleets by horsepower group and year

| Type | HP | Number of vessels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| Otter trawl | <45 | 600 | 621 | 636 | 602 | 298 | 309 | 591 |
| | 46-74 | 164 | 184 | 188 | 137 | 97 | 104 | 101 |
| | 75-140 | 60 | 66 | 76 | 92 | 554 | 581 | 625 |
| | >140 | 56 | 75 | 191 | 468 | | | |

Source: Department of Protection and Development Aquatic Resource of Ca Mau province, 2000.

Bac Lieu Fleets by horsepower group and year

| Type | HP | Number of vessels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| Otter trawl | <45 | | 194 | 196 | 162 | 194 | 138 | 105 |
| | 46-74 | | 108 | 112 | 100 | 72 | 72 | 60 |
| | 75-140 | | 45 | 50 | 53 | 29 | 29 | 23 |
| | >140 | | 30 | 73 | 129 | 222 | 222 | 121 |

The official catch statistics are indicated in Table 3.4.2.

Table 3.4.2. Official catch statistics by fleet, horse power group, province and year
Total catch (tons) and catch composition (pct)

| Province | Product | Year | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| Bac Lieu | Total | | 85.121 | 90.155 | 124.687 | 124.697 | 127.054 | 121.313 |
| | Fish | | 60.3 | 0.0 | 67.7 | 75.0 | 70.9 | 82.4 |
| | Shrimp | | 24.1 | 0.0 | 11.1 | 11.1 | 10.0 | 7.9 |
| | Squid | | 8.5 | 0.0 | 9.8 | 7.3 | 19.1 | 9.6 |
| | | | | | | | | |
| Ca Mau | Total | | 39.832 | 45.830 | 50.780 | 56.731 | 56.873 | 65.319 |
| | Fish | | | | | | 80.0 | 77.0 |
| | Shrimp | | | | | | 16.5 | 13.6 |
| | Squid | | | | | | 3.5 | 9.4 |

***Enumerator data***

The ALMRV database covers the period 1996 to 2002. It comprises information collected by enumerators relating to catch weight by commercial groups, effort (duration of trips), costs and earnings of the most important fleets in the most important landing places in all 28 coastal provinces in Vietnam.

As a general rule, each month the enumerators carry out 20 interviews for each fleet included in the sampling programme but the actual number may be less due to sampling difficulties of various natures. The interviews are made with the captains of vessels just having returned from a fishing trip and relate to the most recent trip only.

Before landing the catch the fishermen sort it into catch groups by genera. If certain species in a catch group appear in sufficient numbers they are sold in separate commercial groups obtaining a higher price. As indicated in text Table 3.4.3 there are five different shrimp catch groups made up by fifteen commercial groups of which eleven is species specific.

To cover the entire shrimp resource in South Vietnam data from two major landing places are included in the present study: Ganh Hao in Bac Lieu province facing the South China Sea and Song Doc in Ca Mau province facing the Gulf of Thailand.

To focus on the shrimp resource, only trips from otter trawlers having shrimp in catches are included in the analysis. 5 otter trawler fleets are defined on basis of vessel size: less than 20HP (OT<20HP), between 20 and 45 HP (OT20-45HP), between 46 and 89 (OT46-89HP), between 90 and 140HP (OT90-140HP) and larger than 140HP (OT>140HP).

The indicators (catch rates of total catch, total shrimp catch, shrimp catch groups and commercial shrimp groups and the turnover) are estimated by fleet as monthly averages. Only estimates based on 5 samples or more are included in the present analysis.

Text table 3.4.3. Shrimp catch groups and commercial groups of the enumerator data collection programme

| Genera | Catch group | Commercial group | Species | English (FAO) | South Vietnamese | Terms from interview statements | Habitat |
|---|---|---|---|---|---|---|---|
| *Panaeus*<br>(Nhom tom he) | White shrimp | Tiger shrimp | *monodon* | Giant Tiger Prawn | Tom su | Su shrimp | B |
| | | | *semisulcatus* | Green tiger prawn | Tom ran | | B |
| | | White banana prawn | *merguiensis* | Banana prawn | Tom The | The shrimp | A |
| | | Kuruma prawn | *japonicus* | Kuruma prawn | Tom He Nhat | The shrimp | B |
| | | White prawn | *indicus*<br>*penicillataus*<br>*orientalis*<br>*teraoi*<br>*plebojus*<br>*canaliculatus*<br>*longistylus*<br>*latisulcatus* | Indian white prawn | Tom The do duoi | The shrimp | A<br>A<br>A<br><br>B<br>B<br>B<br>C |
| *Metapenaeus*<br>(Nhom tom chi) | Pink shrimp | Greasyback shrimp | *ensis* | Greasyback shrimp | Tom Dat (rao) | Dat shrimp | A |
| | | Jinga shrimp | *affinis* | Jinga shrimp | Tom hi bong | Chi bong shrimp | A |
| | | Pink prawn | *intermetius*<br>*lysianassa*<br>*joyneri,*<br>*monoceros*<br>*malaccaensis*<br>*buckenroadi* | Bird shrimp | Tom Bac | Bac shrimp | <br><br>A<br>A<br>A<br>A |
| | Yellow shrimp | Brevicornis | *brevicornis* | Yellow shrimp | Tom bac nghe | Bac nghe shrimp | |
| | | tenuipes | *tenuipes* | Stork shrimp | Tom bac | Bac shrimp | A |
| *Parapenaeopsis*<br>(Nhom tom sat) | Cat shrimp | sculptilis | *sculptilis* | Rainbow shrimp | Tom sat | Sat shrimp | A |
| | | Cat prawns | *cornuta*<br>*gracillima*<br>*tenella*<br>*longipes*<br>*fissarus* | Coral shrimp | Tom Chi<br>Tom Giang | Chi shrimp<br>Giang shrimp | <br>A<br><br>B<br>B |
| | Low value shrimp | Dog shrimp | *hungerfordi* | Dog shrimp | Tom Gay tre | Gay tre shrimp | |
| | | Spear shrimp | *hardwickii* | Spear shrimp | Tom Chi | Tom Chi | A |
| *Trachypenaeus*<br>(Nhom tom choan) | | Southern rough shrimp | *curvirostris* | Southern rough shrimp | Tom giang da | Gay da shrimp | |
| n/a | | Low value shrimp | | | | | |

### *3.4.4 Catch rates of shrimp fleet*
### *Bac Leu*

*Total catch rates*

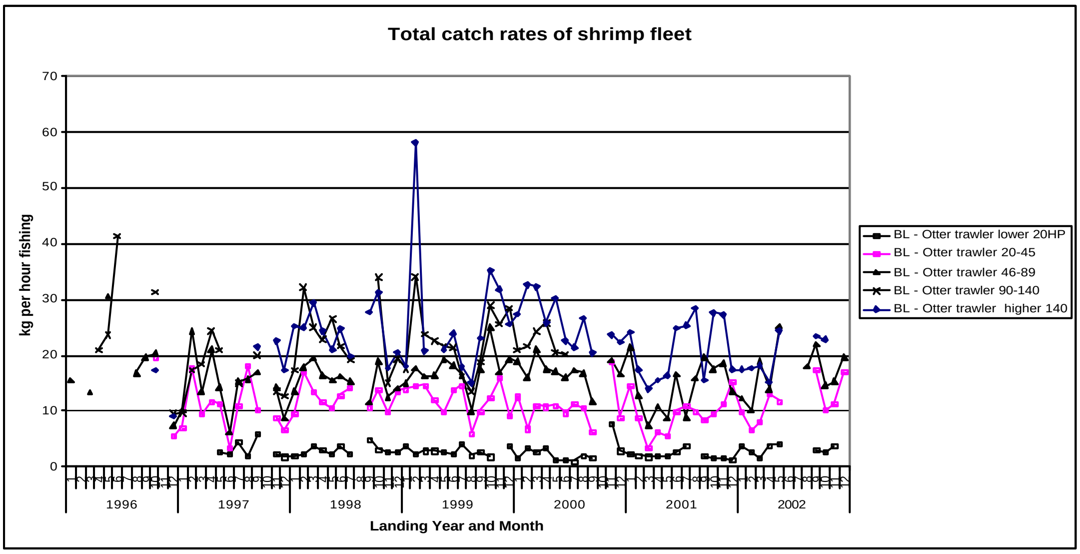



Figure 3.4.1

*Figure 3.4.1:* Total catch rates of shrimp otter trawlers are in the range of 5 to 22kg/hour dependant on vessel size. There is no tend in total CPUE level over time but the large trawlers had slightly higher catch rates in the second half of 1999 and in the first half of 2000. After 2000 the CPUE for these fleets seem to have stabilised at the same low level they had before.

*Shrimp catch rates*

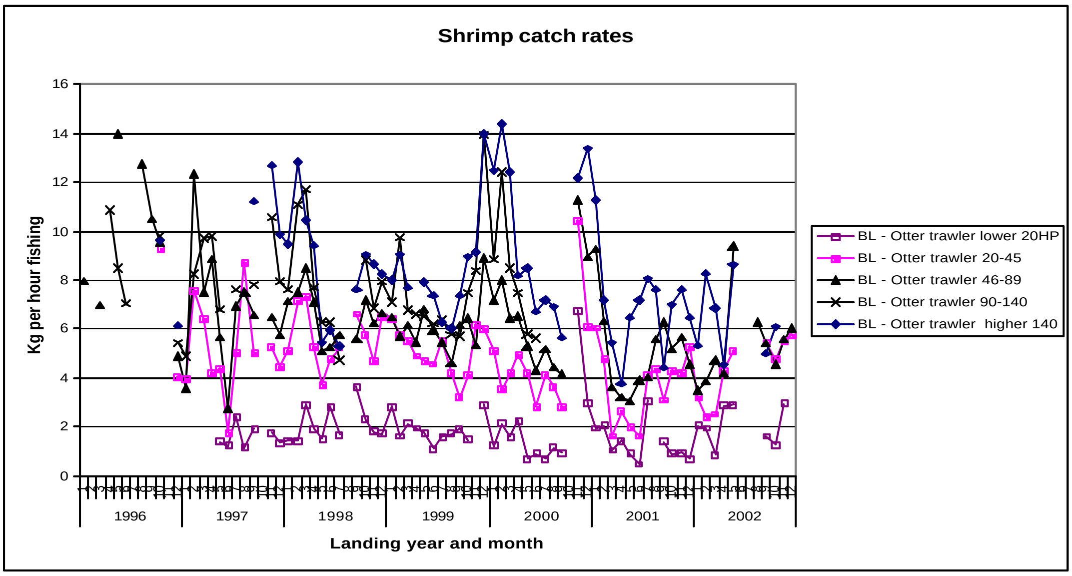



Figure 3.4.2

*Figure 3.4.2:* Shrimp catch rates are dependant on vessel size. There are indications of seasonal variation in the shrimp catch rates. They tend to increase by the end of a calendar

year and decrease during the first few month of the following year. This could be investigated further by Anova analysis. After the second half of 2001 no peaks in catch rates were observed and they have fluctuated at the normal in between peak levels about 2kg/hour for OT<20HP/hour and between 4 and 8kg/hour for the other fleets. This could be an indication of recruitment failure.

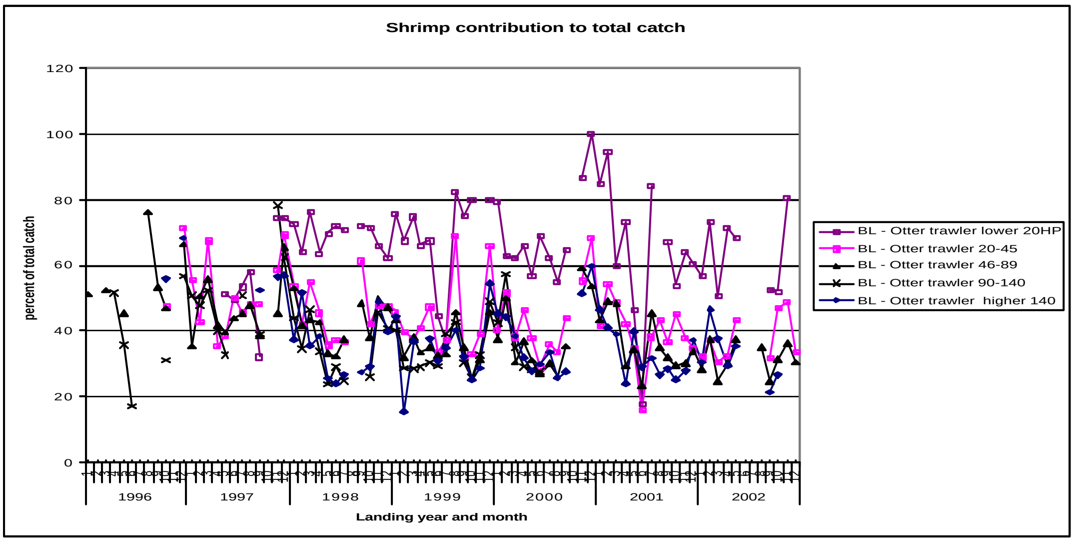



Figure 3.4.3

*Figure 3.4.3:* Measuring shrimp catch rates (Figure 3.4.2) against total catch rates (Figure 3.4.1) indicate that although the smallest vessels have the lowest catch rates they have the highest (60-80%) proportion of shrimp in the catches. For the larger vessels the average proportion of shrimp in the catches was about 50% before 1998. After 1998 the shrimp contribution fluctuated between 25 and 40%. During the seasonal peaks the proportions of shrimp rose to about 60%.

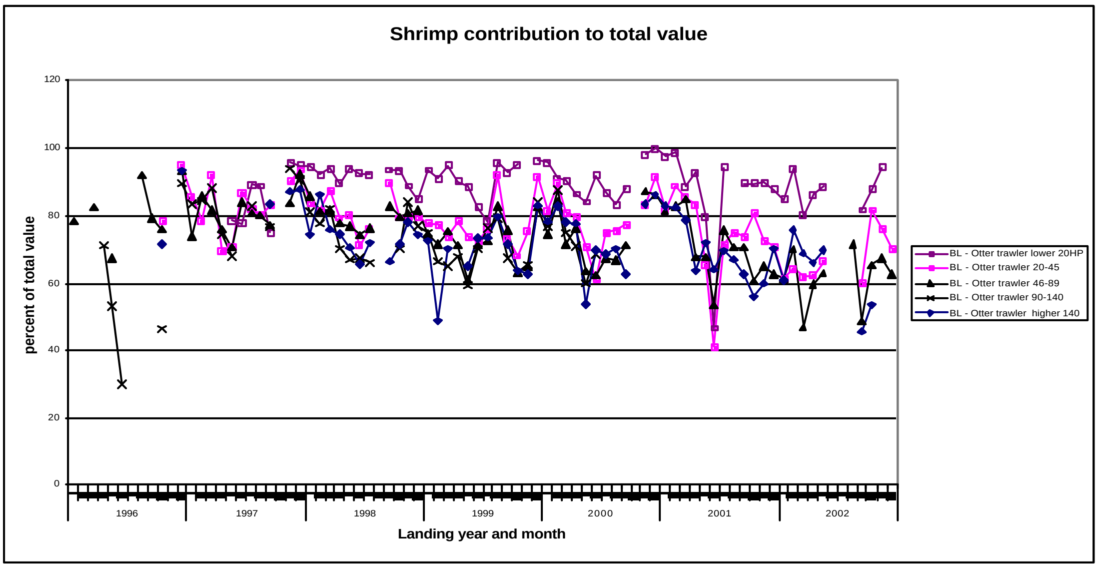



Figure 3.4.4

*Figure 3.4.4:* For all shrimp fishing fleets the shrimp catches were by far the most important catch group from an economic perspective although all but the smallest vessels (OT20HP)

have encountered a decrease in the shrimp contribution to the economic value. For all fleets the seasonality of the catch rates are reflected clearly in the shrimp value contributions until end of 2000. The economic impact of the recruitment failure is reflected by the lack of seasonal peaks since 2001.

*Shrimp group catch rates*

Cat Prawn

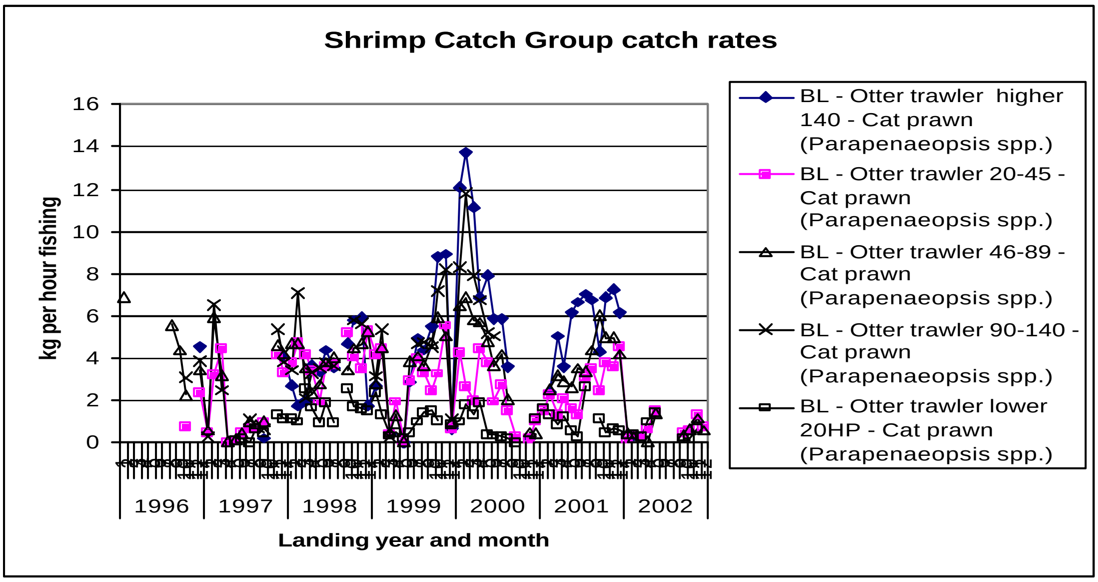



Figure 3.4.5

*Figure 3.4.5:* The Cat Prawn catch rates show seasonal variation with peaks about 6kg/hour followed by periods of very low catch rates. In the period 1999 to 2000 Cat Prawn catch rates of the larger trawlers were particular high (12-14kg/hour) and only 1 month (November 1999) were having low catch rates. After the decline in catch rates by end of 2001 they have remained at a very low level throughout 2002.

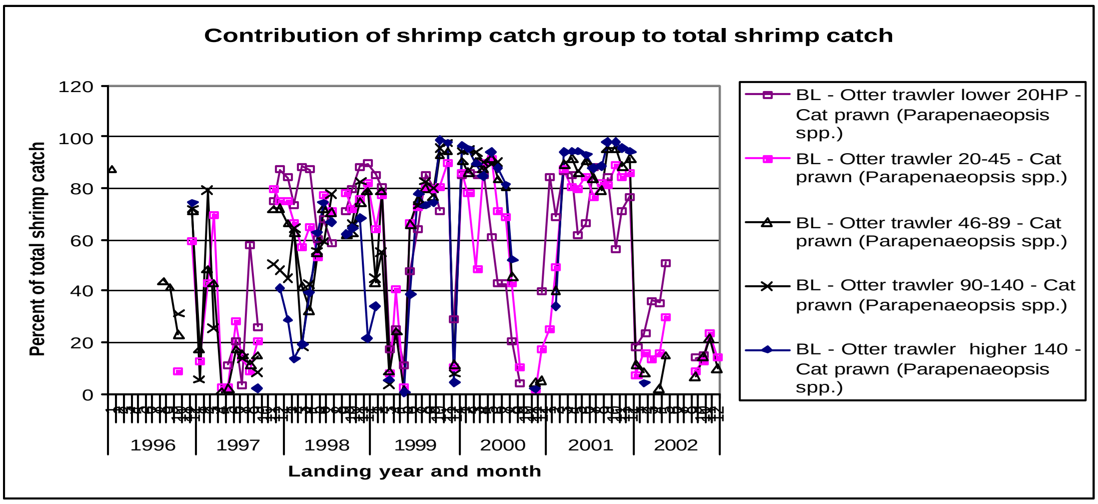



Figure 3.4.6

*Figure 3.4.6:* Measuring Cat Prawn catch rates (Figure 3.4.5) against the total shrimp catch rates (Figure 3.4.2) indicate that for all fleets Cat Prawns are by far the most abundant in the catches until end of 2001. During the peak seasons more than 90% of the shrimp catches belong to the Cat Prawn catch group. Each peak season are separated by the next by a few months with low catch rates.

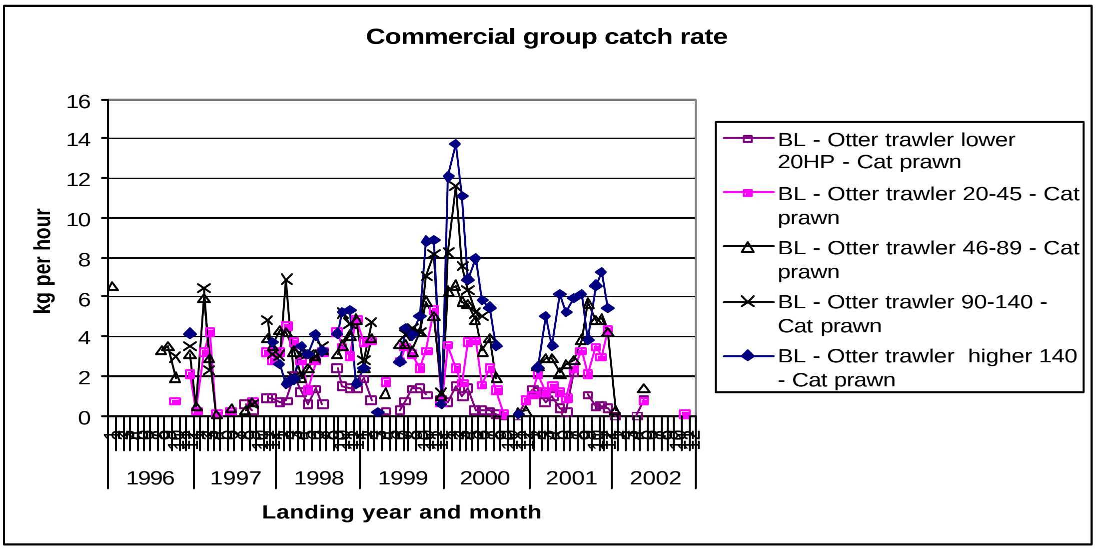



Figure 3.4.7

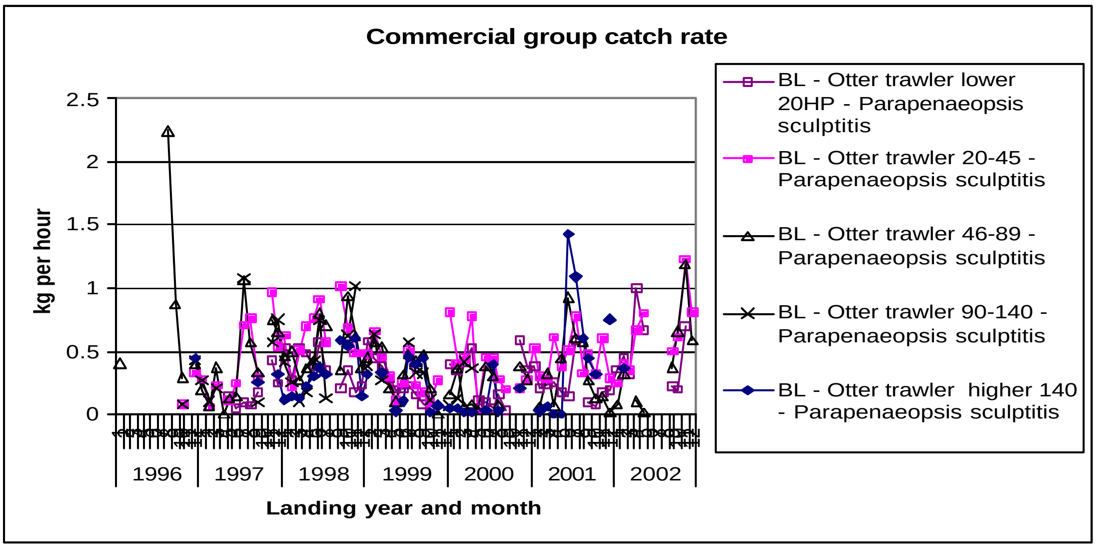



Figure 3.4.8

*Figures 3.4.7-3.4.8:* The Cat Prawn catch group consists of two commercial groups: Cat Prawn and *Parapenaeopsis sculptitis*. Figure 3.4.7 indicate that the catch rate peaks of cat prawns indicated in Figures 3.4.5 and 3.4.6 were almost entirely comprised of the cat prawn commercial group, whereas the catch rates of the more valuable *P. sculptitis* were rather constant at a level less than 1kg. (It can not be ruled out that the little lower catch rates of *P. sculptitis* in 1999 and 2000 (0-0.5 kg per hour) might reflect that more were sold as the cat prawn commercial group.)

As indicated in Figure 3.4.7 the low Cat Prawn catch rates in 2002 (Figure 3.4.5 and 3.4.6) was due to low catch rates of the Cat Prawn commercial group. Since beginning of 2002 almost all catch prawns belonged to the *P. sculptitis* commercial group.

(Regrettably the species composition and size distribution of the catch prawn commercial group is not known. As it is not possible to evaluate whether the cat prawn commercial group is comprised of small *P. sculptitis* or of a mixture of other species, it is difficult to evaluate the dynamics.)

Low Value Shrimp

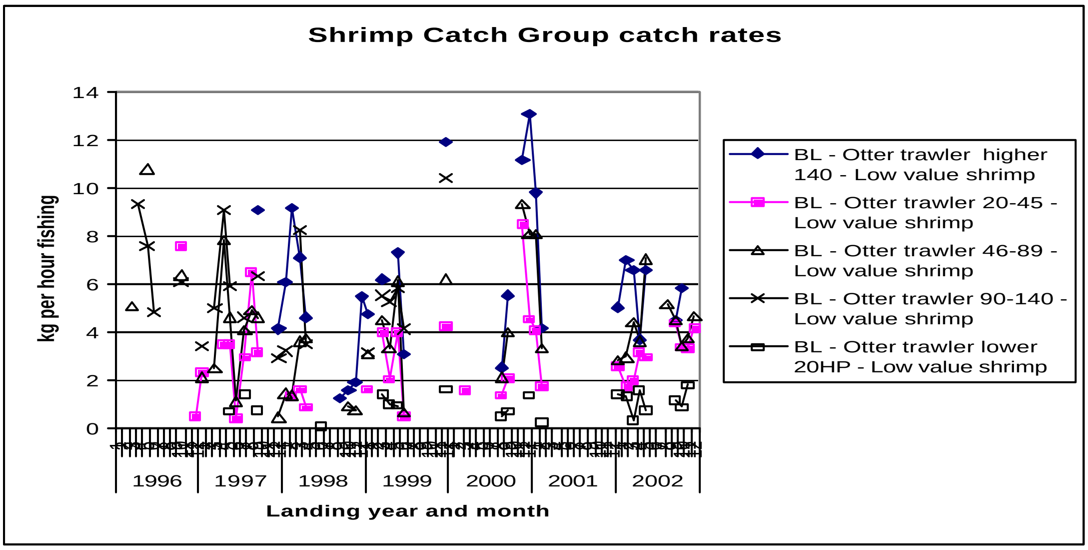



Figure 3.4.9

*Figure 3.4.9:* The catch rates of the Low Value Shrimp show clear seasonal variations with fluctuations in counter phase with the Cat Prawns. During whole of 2002 the catch rates of Low Value Shrimp remained high.

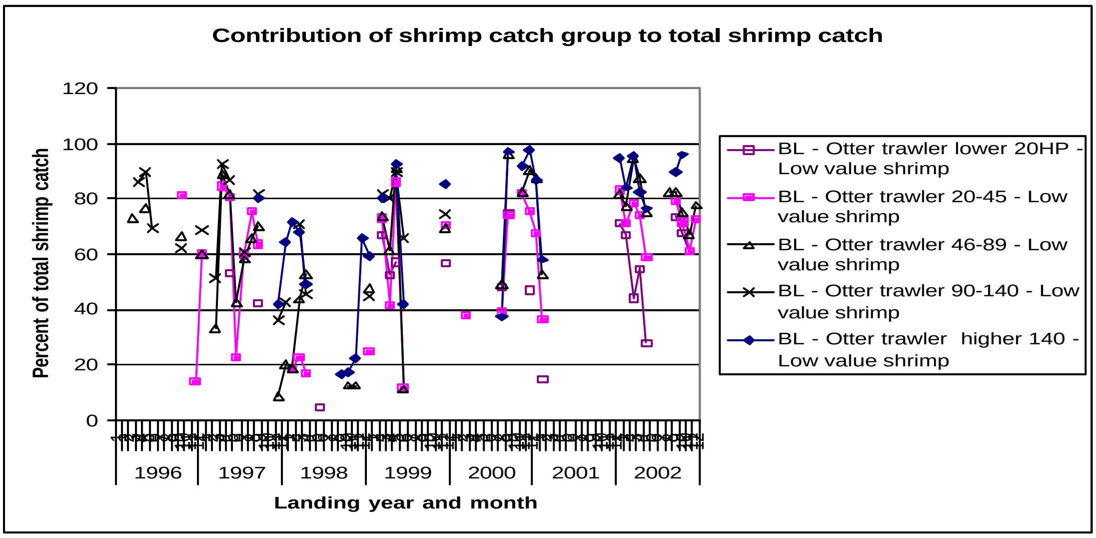



Figure 3.4.10

*Figure 3.4.10:* Measuring Low Value Shrimp catch rates (Figure 3.4.9) against total shrimp catch rates (Figure 3.4.2) indicates that the Low Value Shrimp comprise the major part of the shrimp catches in times of low Cat Prawn contributions.

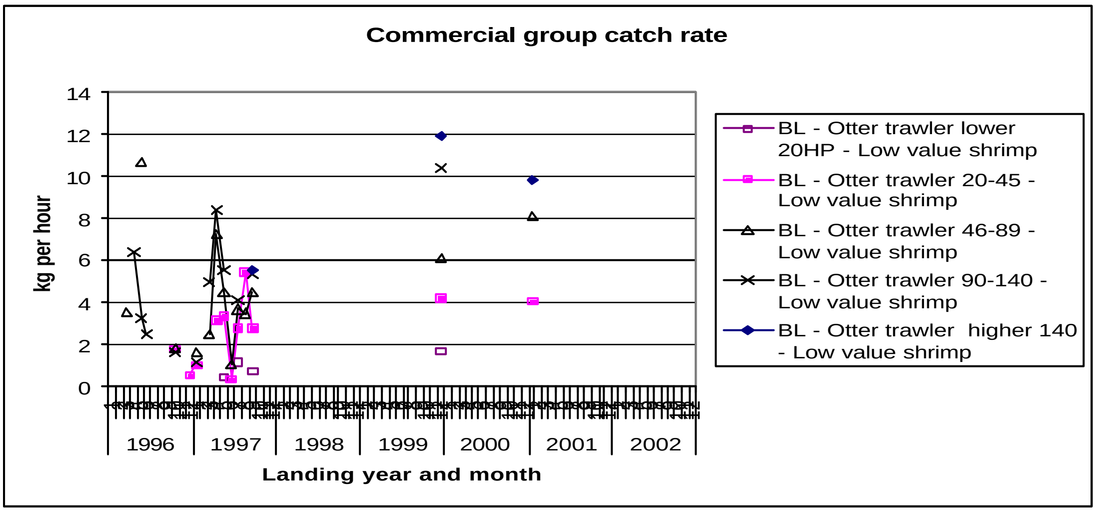



Figure 3.4.11

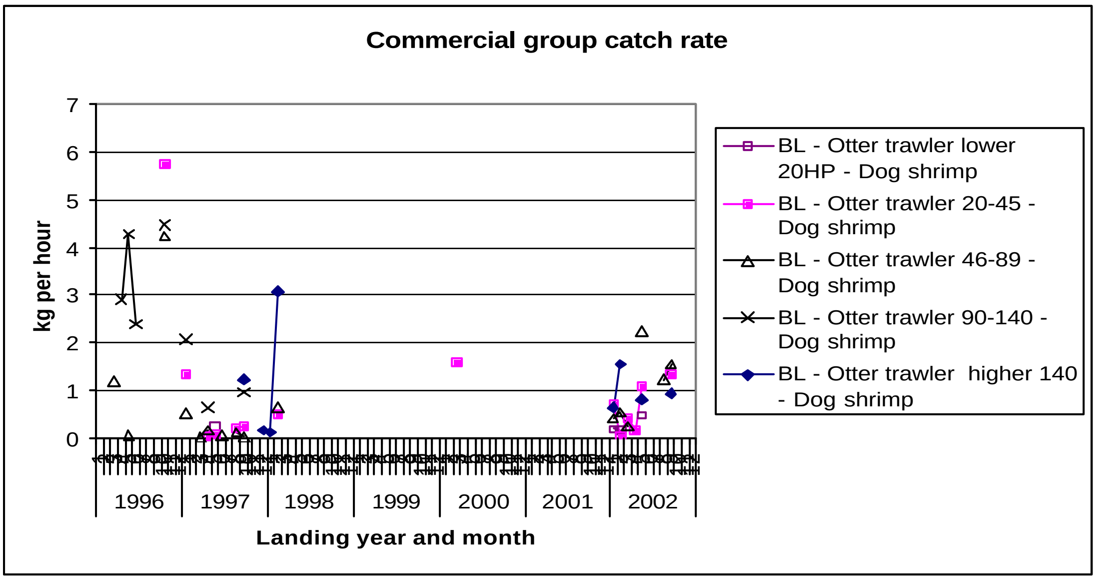



Figure 3.4.12

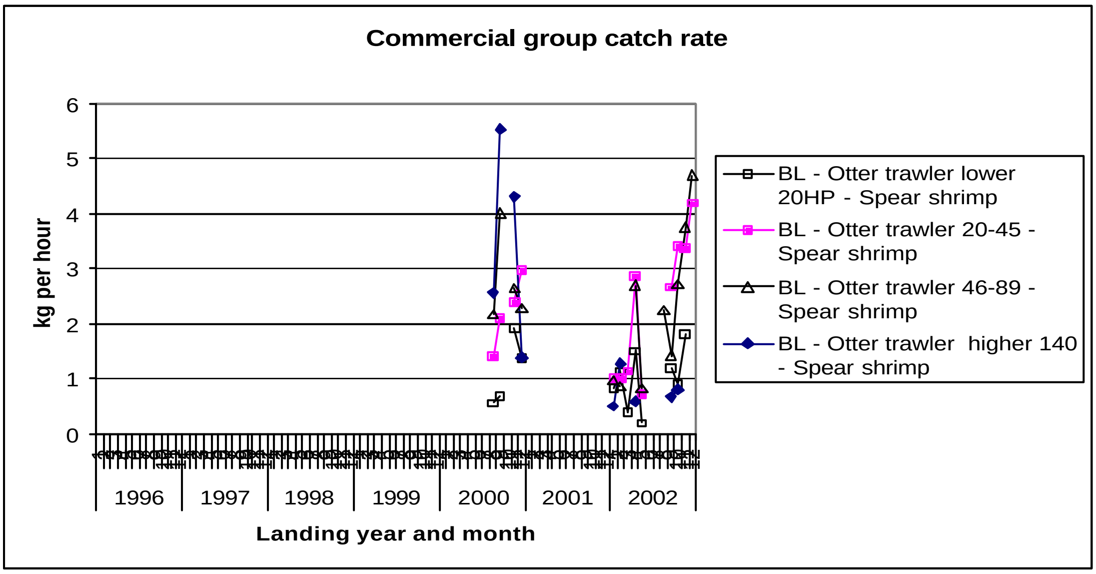



Figure 3.4.13

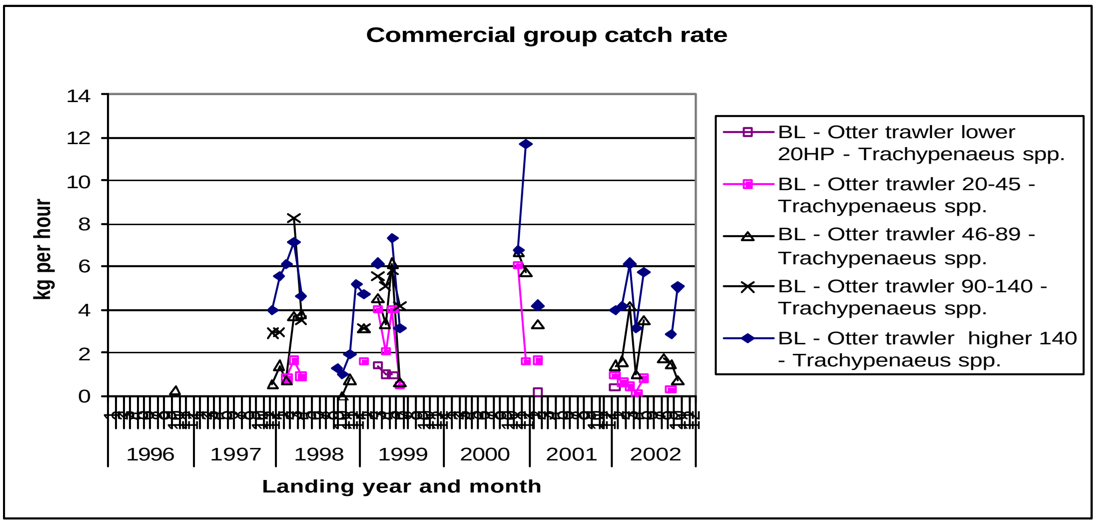



Figure 3.4.14

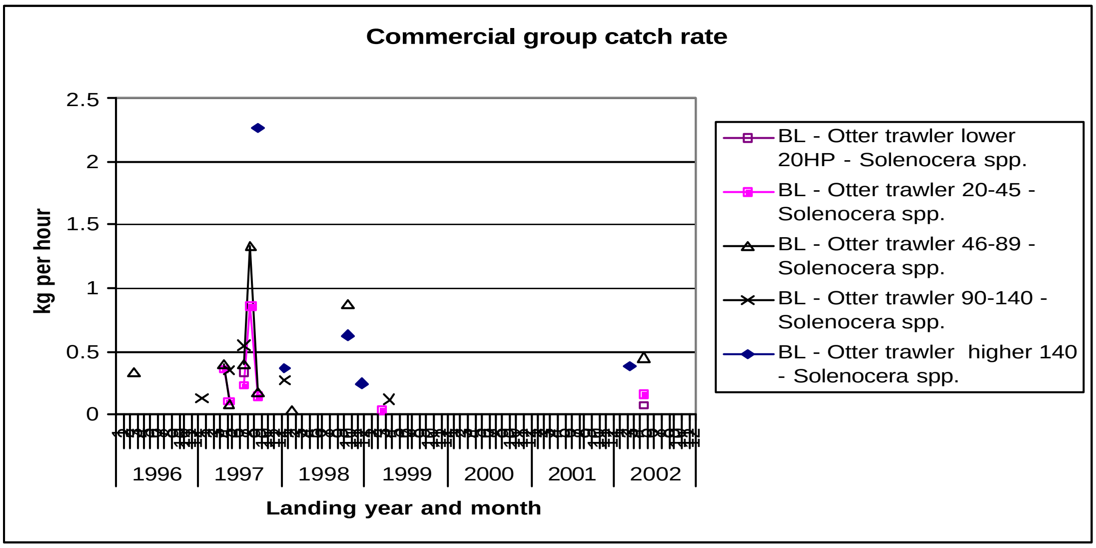



Figure 3.4.15

*Figure 3.4.11-3.4.15:* The commercial group composition of the Low Value Shrimp catch group have changed considerably since 1996. In 1996 and first half of 1997 this catch group consisted primarily of the commercial groups Low Value Shrimp (Figure 3.4.11), dog shrimps (Figure 3.4.12) and Solenocera spp. (Figure 3.4.15). From second half of 1997 until middle of 1999 it consisted almost entirely of the Trachypenaeus spp commercial groups (Figure 3.4.14). Since middle of 2000 the Trachypenaeus spp and Spear shrimp (Figure 3.4.13) commercial groups contributed the most and Dog shrimp a little in 2002.

Pink Prawn

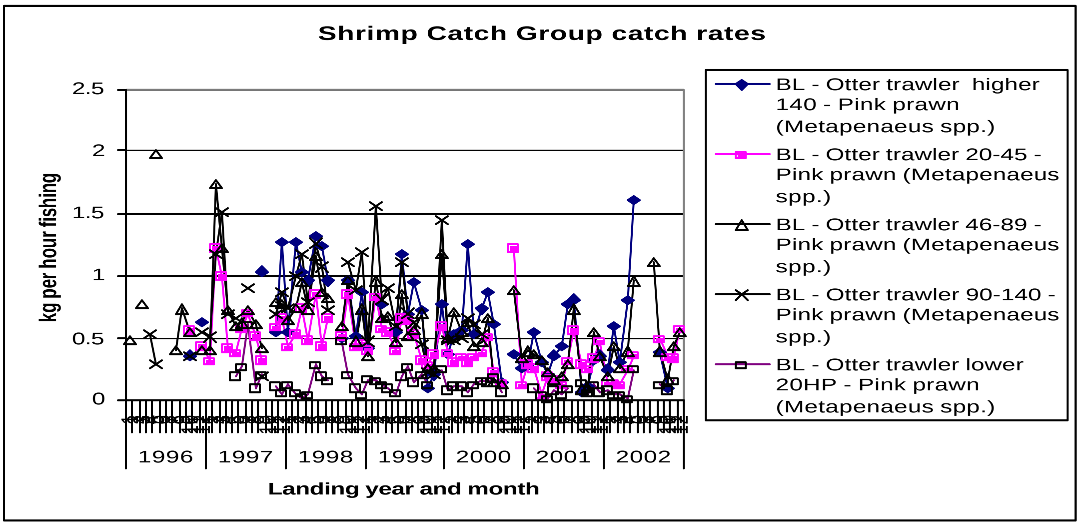



Figure 3.4.16

*Figure 3.4.16:* Pink Prawn catch rates for the small trawlers (OT<20HP) have remained at a low level (less than 0.25kg/hour) since 1997. The catch rates for the other fleets have declined from a level fluctuating around 1kg/hour in 1998 to a new catch rate level between 0 and 0.5kg/hour by end of 2000.

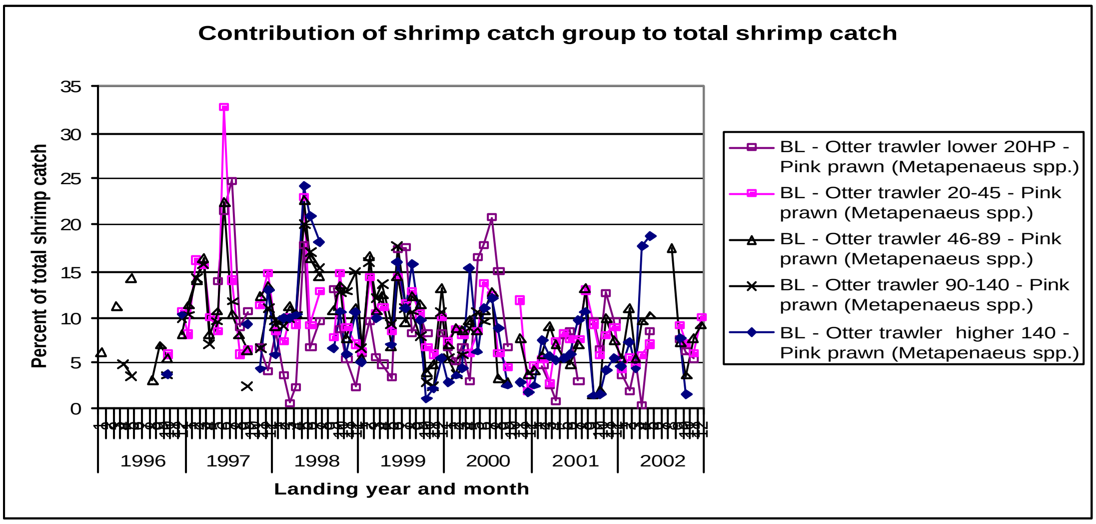



Figure 3.4.17

*Figure 3.4.17:* Measuring Pink Prawn catch rates (Figure 3.4.16) against total shrimp catch rates (Figure 3.4.2) also demonstrate the declining catch rates. For all fleets the proportion of Pink Prawn declined from a level about 10-20% in 1997 to about 5-10% in 2000. After 2000 the proportion of Pink Prawn remained at the lower level.

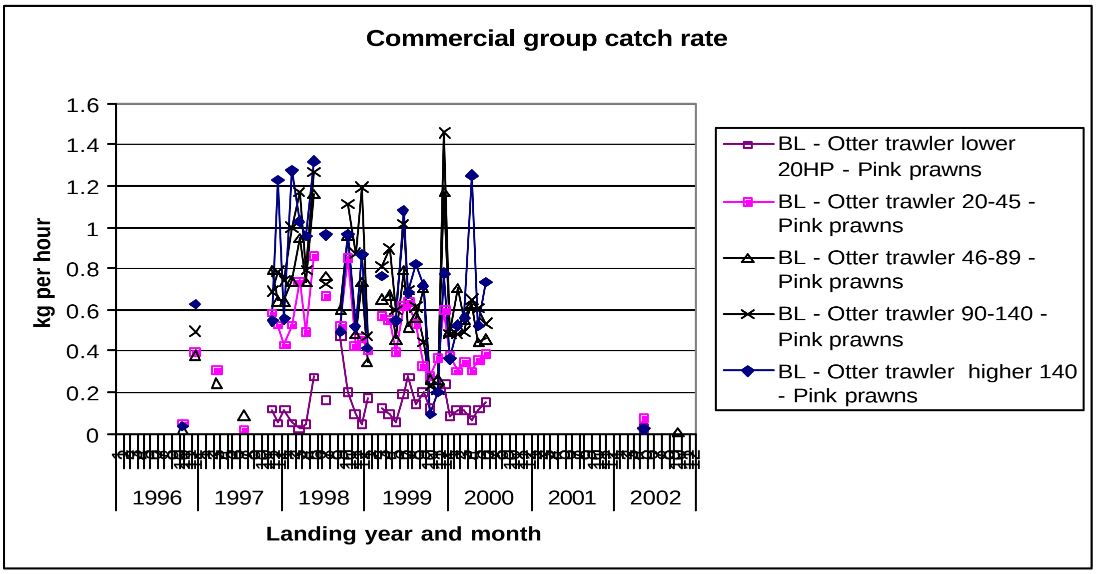



Figure 3.4.18

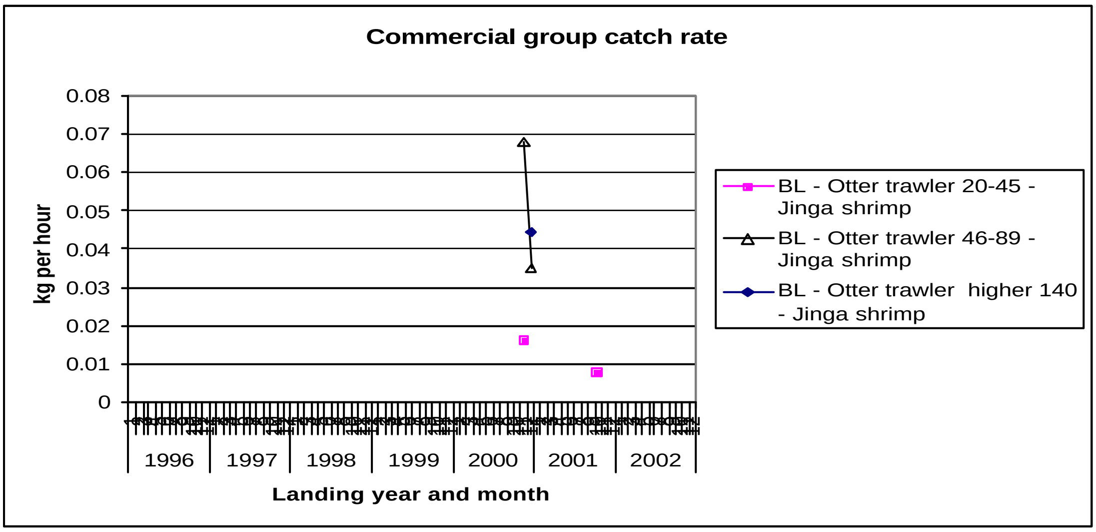



Figure 3.4.19

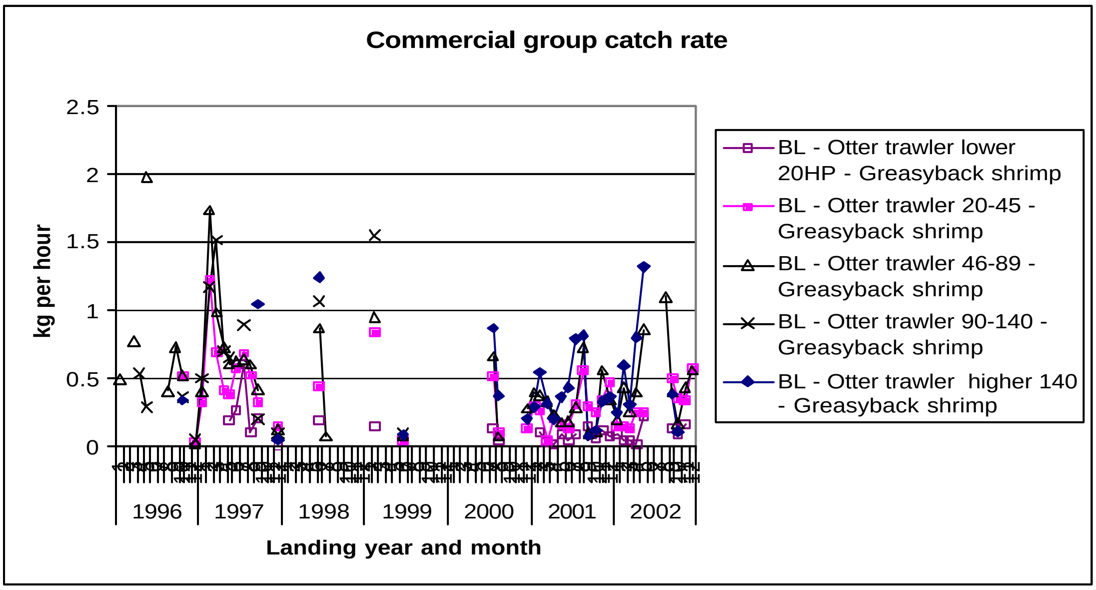



Figure 3.4.20

*Figure 3.4.18-3.4.20:* The Pink Prawn catches were comprised almost entirely by the pink prawn commercial group from end of 1997 to middle of 2000 (Figure 3.4.18). Before and after this period they were almost entirely comprised by the Greasy Back commercial group (Figure 3.4.20).

There is no price difference between the Pink Prawn and the Greasy Back commercial groups and therefore no obvious incentive to sort out.

White Prawn

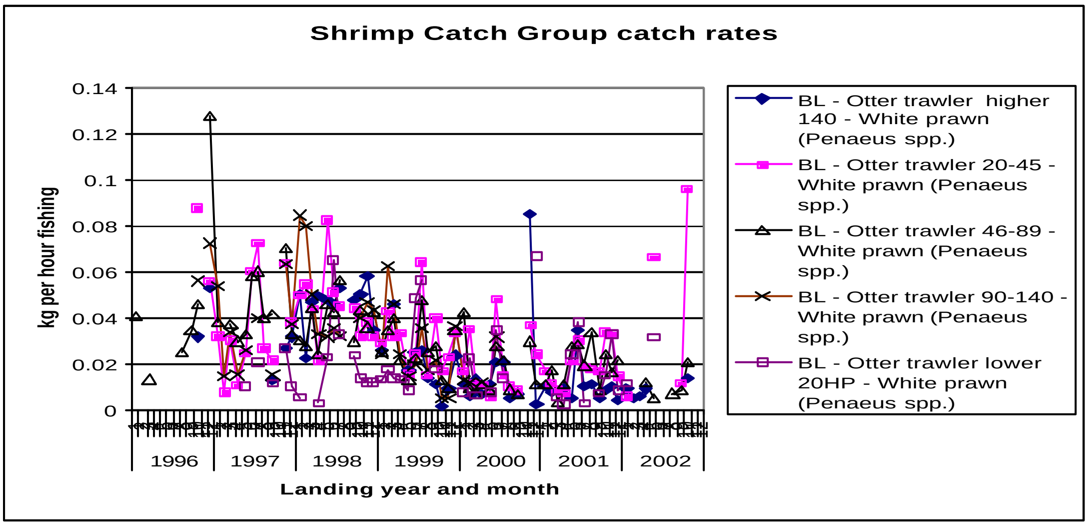



Figure 3.4.21

*Figure 3.4.21:* The catch rates of White Prawn decreased from 1997 to 1999 from a level around 0.05kg/hour to less than the half. There was a minor increase in catch rates in 2001 but again in 2002 the catch rates were at a very low level.

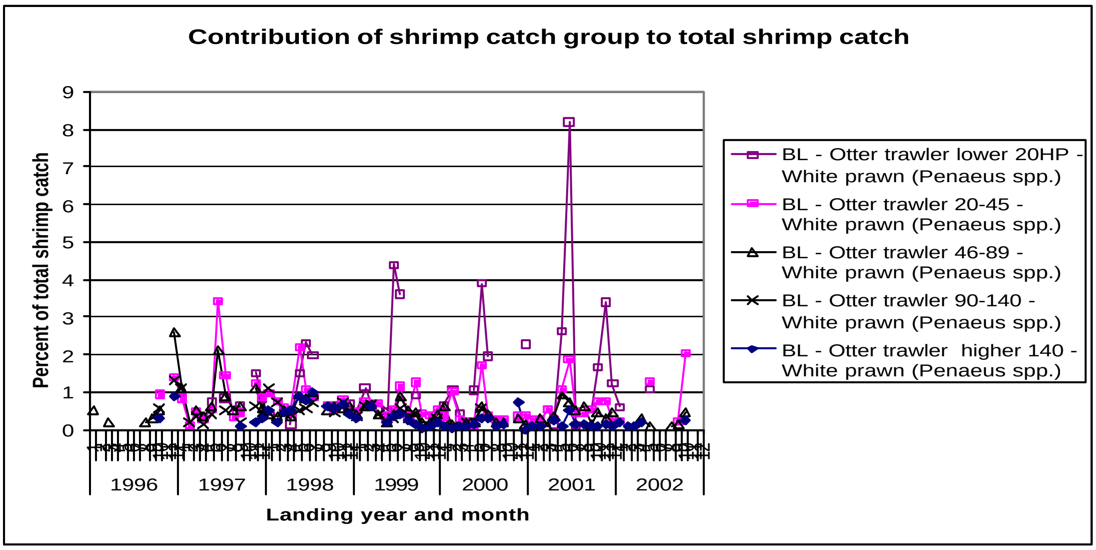



Figure 3.4.22

*Figure 3.4.22:* In general the White Prawn catches comprise less than 1% of the total shrimp catches but occasionally small trawlers had catches with up to 4%.

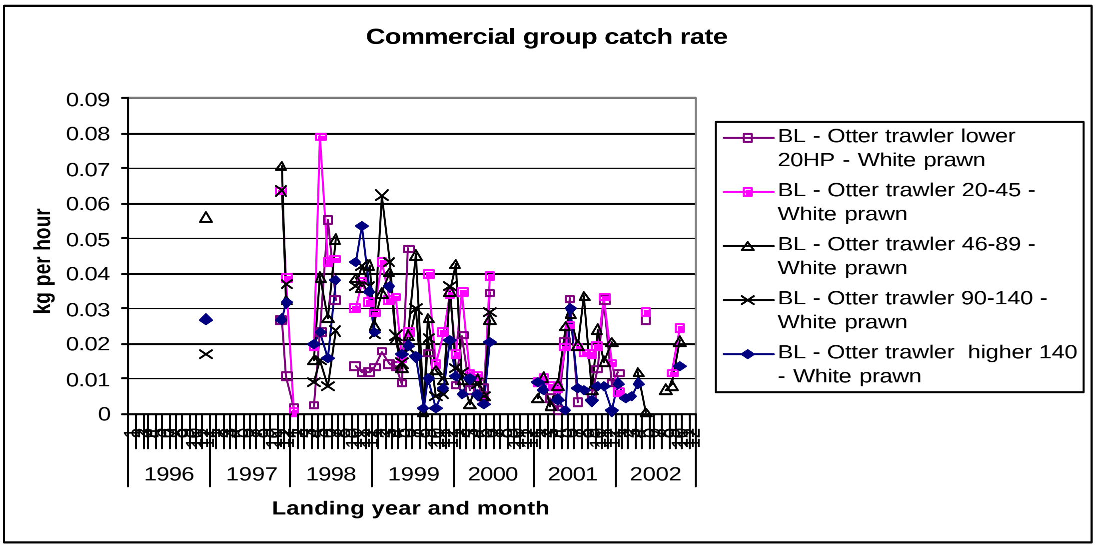



Figure 3.4.23

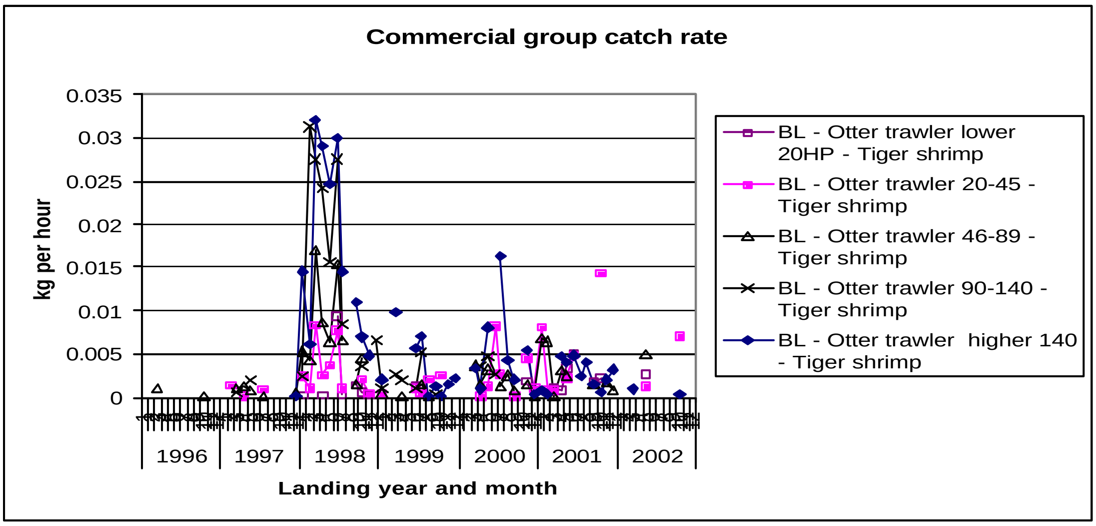



Figure 3.4.24

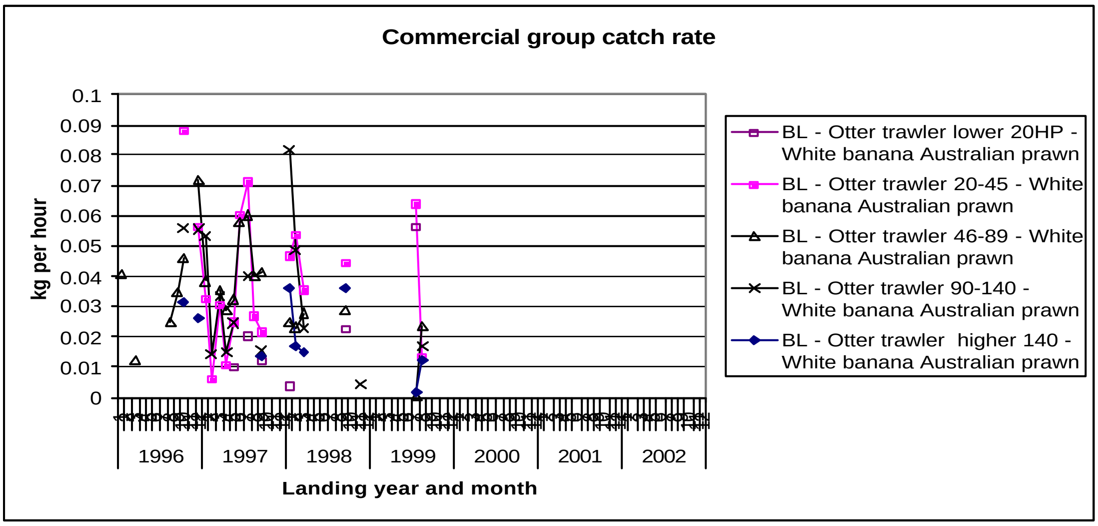



Figure 3.4.25

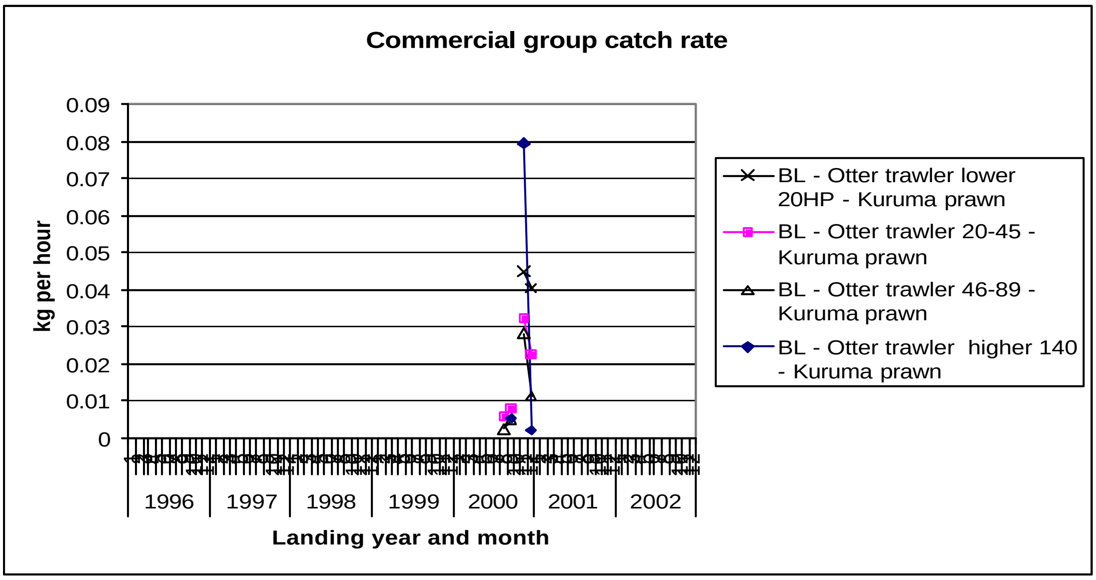



Figure 3.4.26

*Figure 3.4.23-3.4.26:* The White Prawn catch group consisted in 1996 and 1997 primarily of the White Banana Australian Prawn commercial group (Figure 3.4.25). Since beginning of 1998 most White Prawn were sold as the White Prawn commercial group.

The Tiger Shrimp commercial group mostly comprised between 0 and 20% of the White shrimp catches (Figure 3.4.24). Only for a few months in 1998 the catch rates of Tiger Shrimp were much higher.

There is no price difference between the White Shrimp commercial groups.

Yellow Shrimp

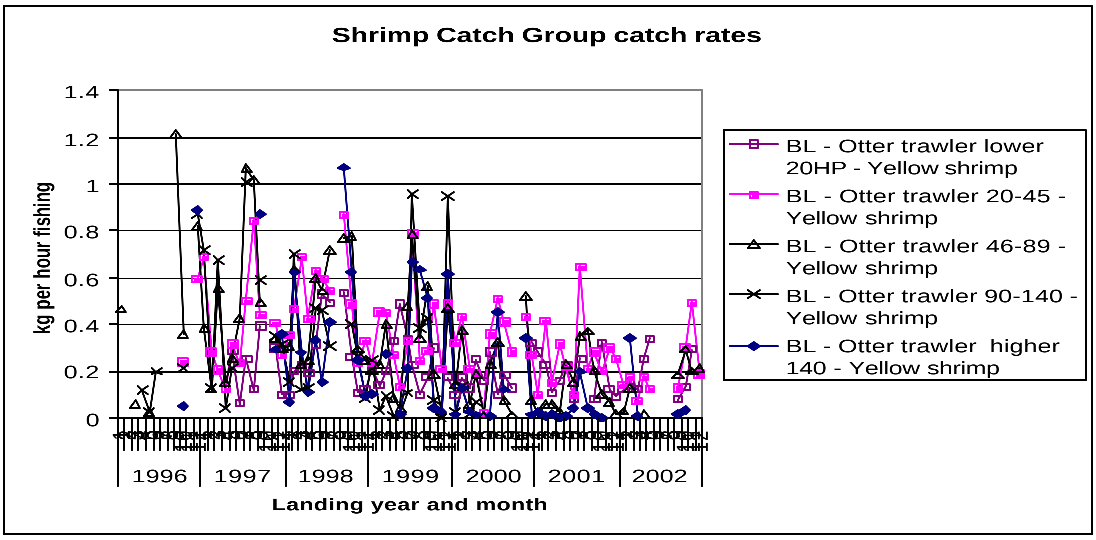



Figure 3.4.27

*Figure 3.4.27:* The average catch rates of Yellow Shrimp declined from about 0.6kg/hour in 1997 to about 0.2 by end of 1999. Since 2000 the catch rates fluctuated between 0 and 0.4kg/hour.

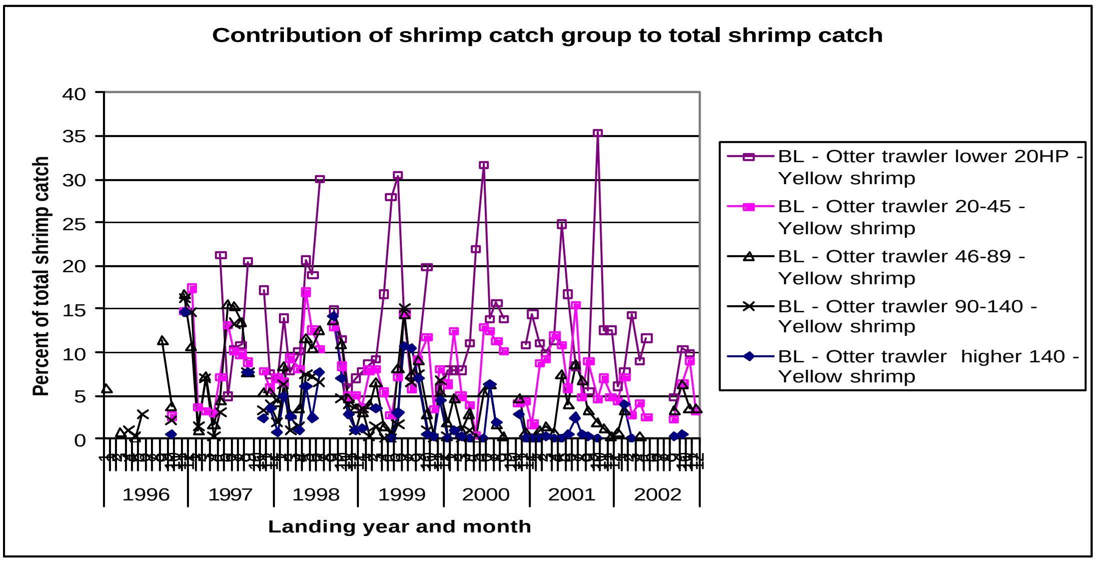



Figure 3.4.28

*Figure 3.4.28:* The Yellow Shrimp have almost entirely disappeared from the catches of the large trawlers and their proportions in the shrimp catches of OT20-45HP fleet have declined from about 10 to 5%. Only the small trawlers seem to have maintained a high catch level of Yellow Shrimp (about 10%) with occasional peaks at 30%.

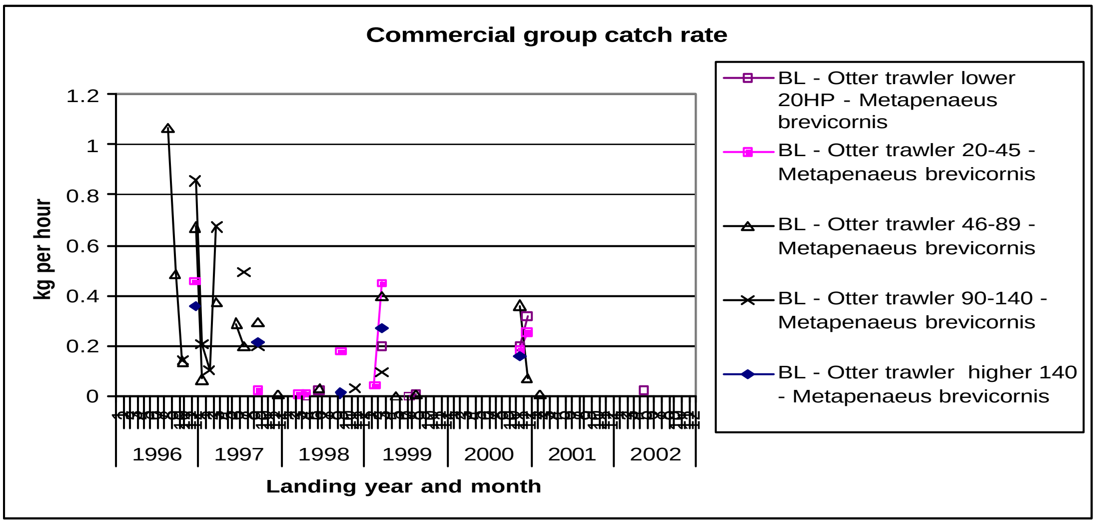



Figure 3.4.29

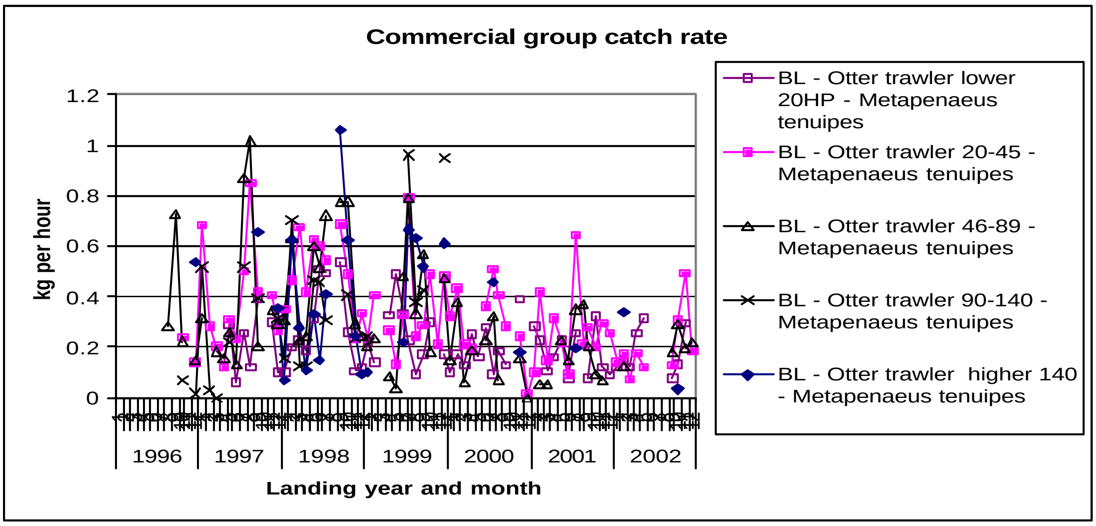



Figure 3.4.30

*Figure 3.4.29-3.4.30:* The Yellow Shrimp catches are comprised almost entirely by the *M. tenuipes* (Figure 3.4.30). Therefore, the decline in this commercial group, from about 0.5 kg per hour in 1997 to about 0.2 kg per hour in 2000, was observed directly in the yellow shrimp catches. Catches of *M. brevicornis* have been reported by the enumerators in only a few months (Figure 3.4.29).

No price differences between the yellow shrimp commercial groups.

***Ca Mau***

*Total catch rates*

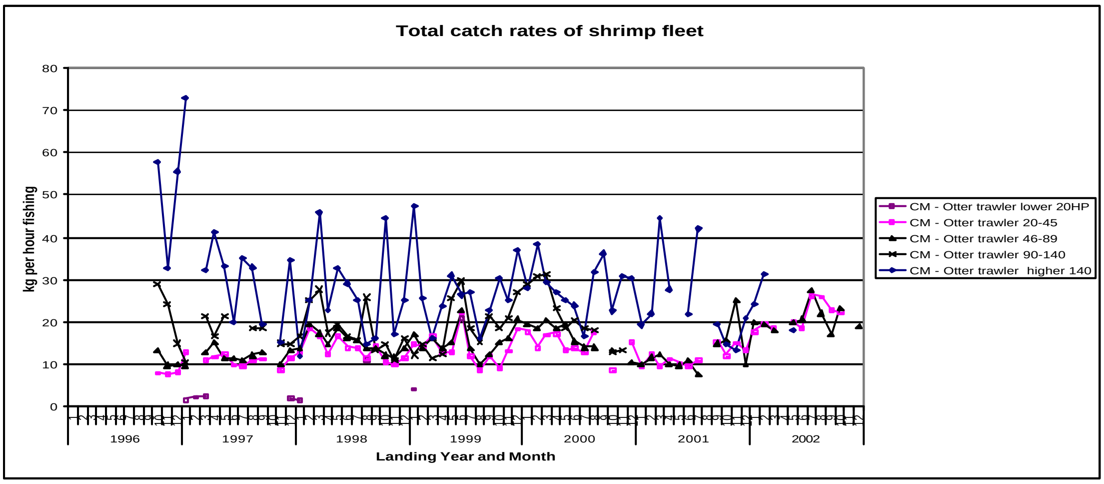



Figure 3.4.31

*Figure 3.4.31:* The total catch rates of all the shrimp fleets in CM have been rather constant since 1997. The CPUE of the two small trawler fleets (OT20-45HP and OT46-89HP) fluctuated between 10 and 20kg/hour. Catch rates of OT90-140HP and OT>140HP fluctuated mostly between 20 and 30 kg/hour but were sometimes as high as 40kg/hour for the OT>140HP. There are few data only for the OT<20HP fleet but they all indicate total catch rates below 5kg/hour.

*Shrimp catch rates*

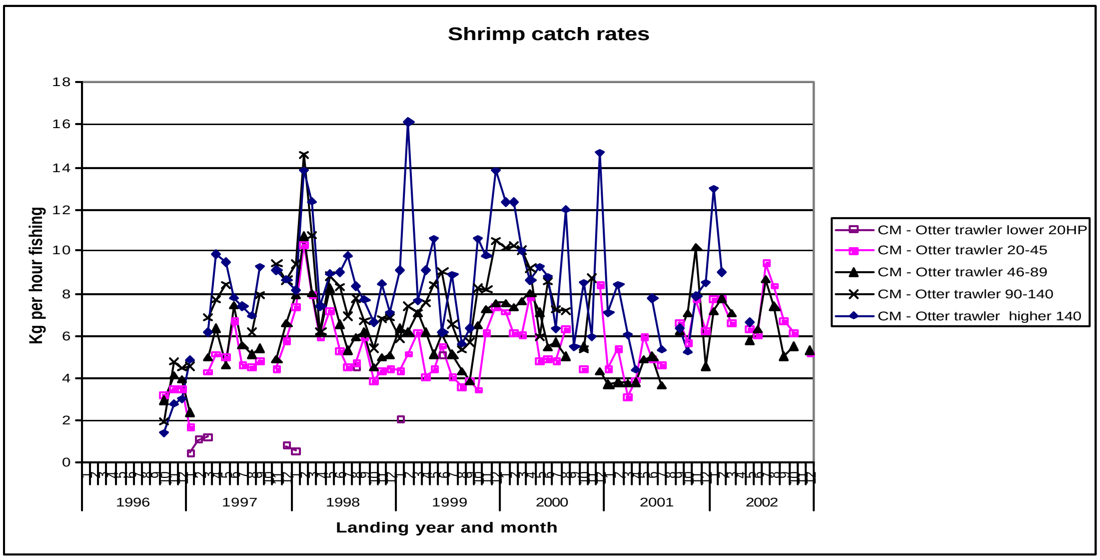



Figure 3.4.32

*Figure 3.4.32:* The CPUE of shrimp have been rather constant since 1997 for all fleets. The catch rates fluctuated between 4 and 10Kg/hour with some peaks about 14kg/hour for the larger trawlers.

The signs of seasonal variability are less clear than in BL, however by the turn of year in 1997/1998 and 1999/2000 increased rates are indicated.

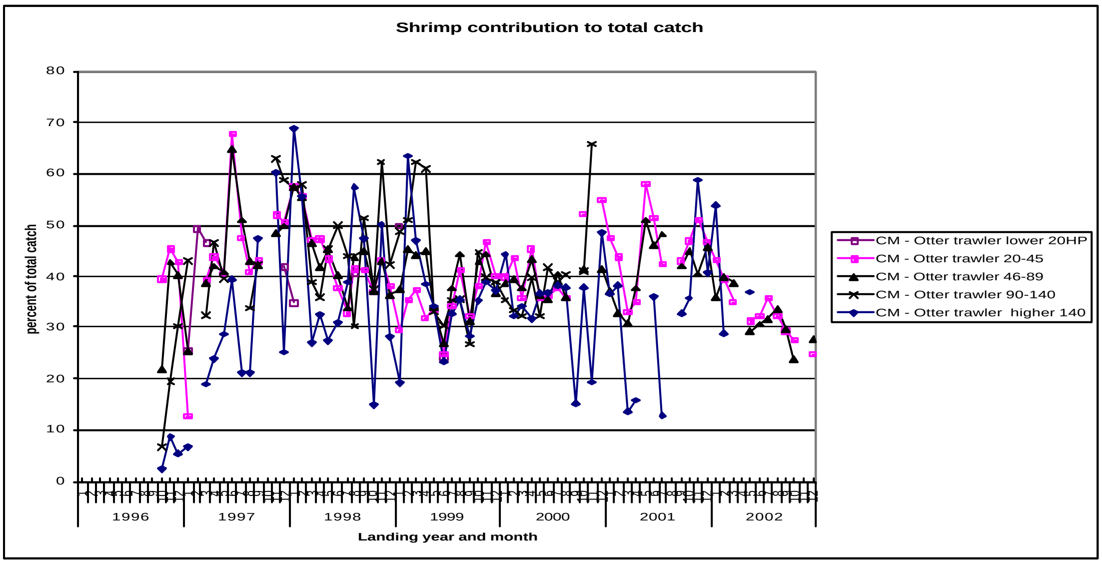



Figure 3.4.33

*Figure 3.4.33:* From 1997 to middle of 1998 the shrimp contribution to total catches increased from 20 to 40% for the large trawlers. During the same period the contribution of the remaining fleets fluctuated around 45 percent. By middle of 1999 the large fluctuations decreased and the proportion of shrimp remained between 30 and 50% until second half of 2000. In second half of 2000 and until end of 2001 an increase of the average shrimp contribution to almost 50% for HP 20-45 and HP 46-89 was observed. In this period the variability for the large trawlers increased significantly. In some month the shrimp contribution was at the same average level as for the other fleets but in other months it was as low as 15%. In 2002 there was a gradual decrease in shrimp contribution to less than 30 percent for the only two fleets with data.

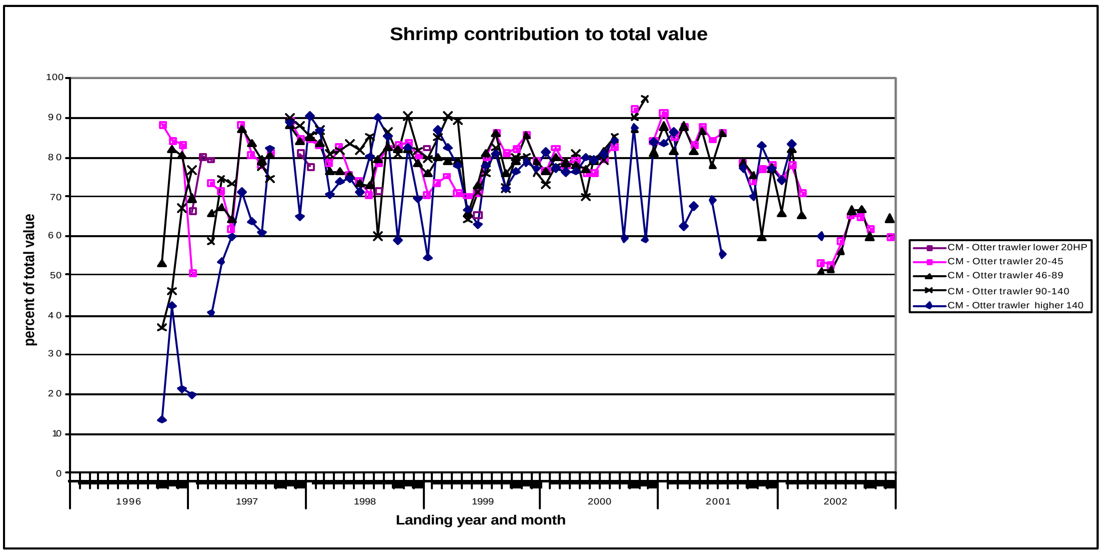



Figure 3.4.34

*Figure 3.4.34:* From 1998 to end of 2000 the economic contribution of the shrimp catches to the total catch value have fluctuated between 70 and 90%. By end of 2000 the shrimp value contribution for the larger trawlers were often as low as 60%. During 2002 many vessels left the shrimp fishery and the enumerators collect data from OT20-45HP and OT46-89HP only. For these fleets the shrimp value contribution declined to a level between 50 and 50%.

*Shrimp group catch rates*

Cat Prawn

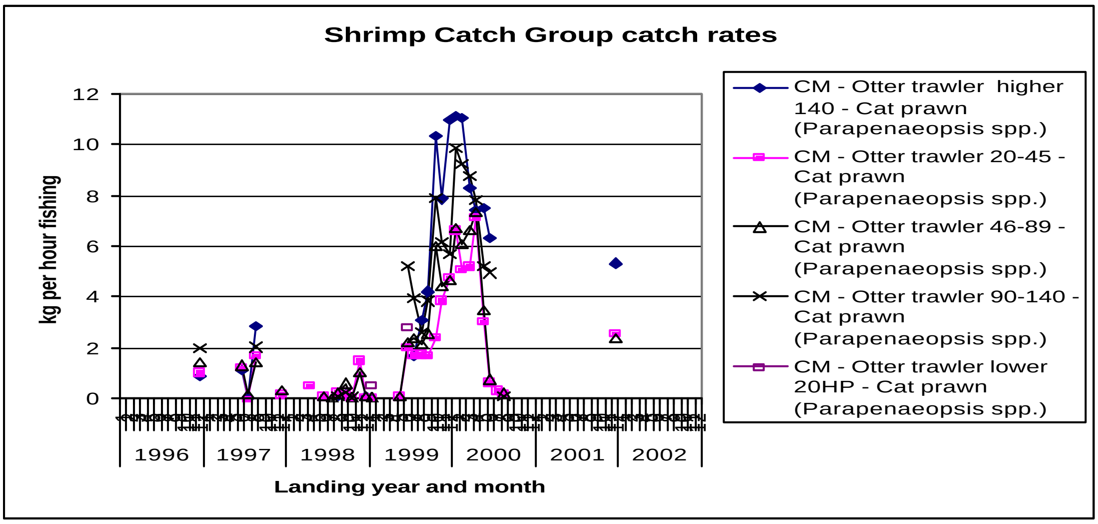



Figure 3.4.35

*Figure 3.4.35:* The Cat Prawn catch rates have been insignificant except during the period from middle of 1999 to middle of 2000 when they suddenly rose from virtually nothing to more than 10kg per hour. Apparently, after this peak they disappeared entirely from the catches again.

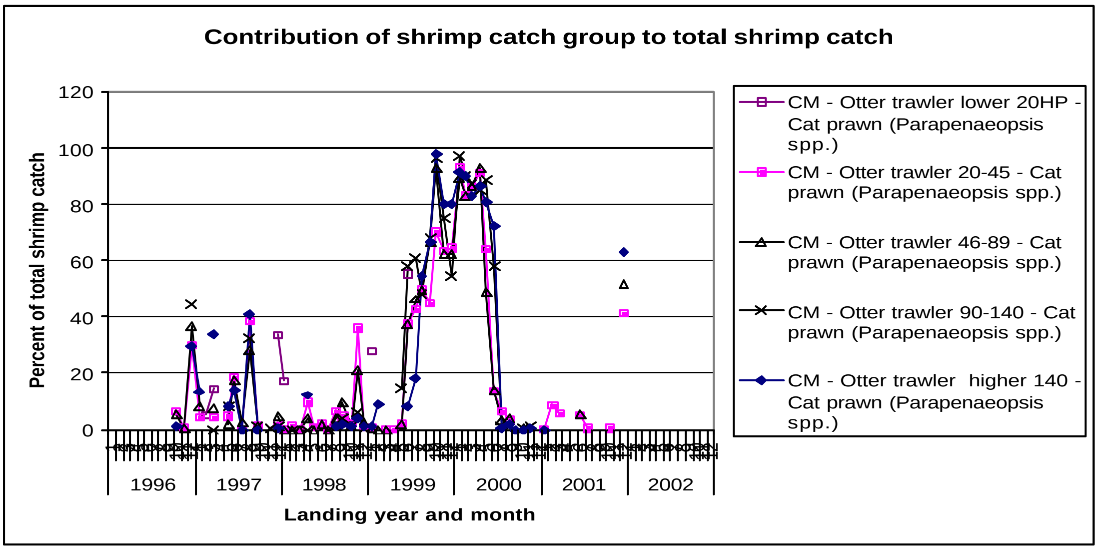



Figure 3.4.36

*Figure 3.4.36:* During the 1999/2000 peak period almost the entire shrimp catch was comprised by the Cat Prawns.

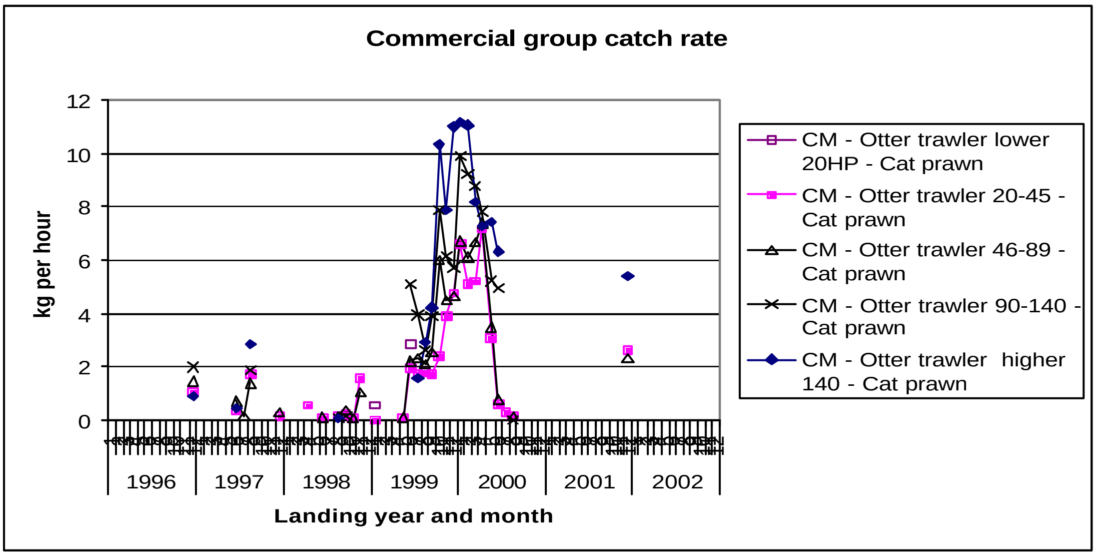



Figure 3.4.37

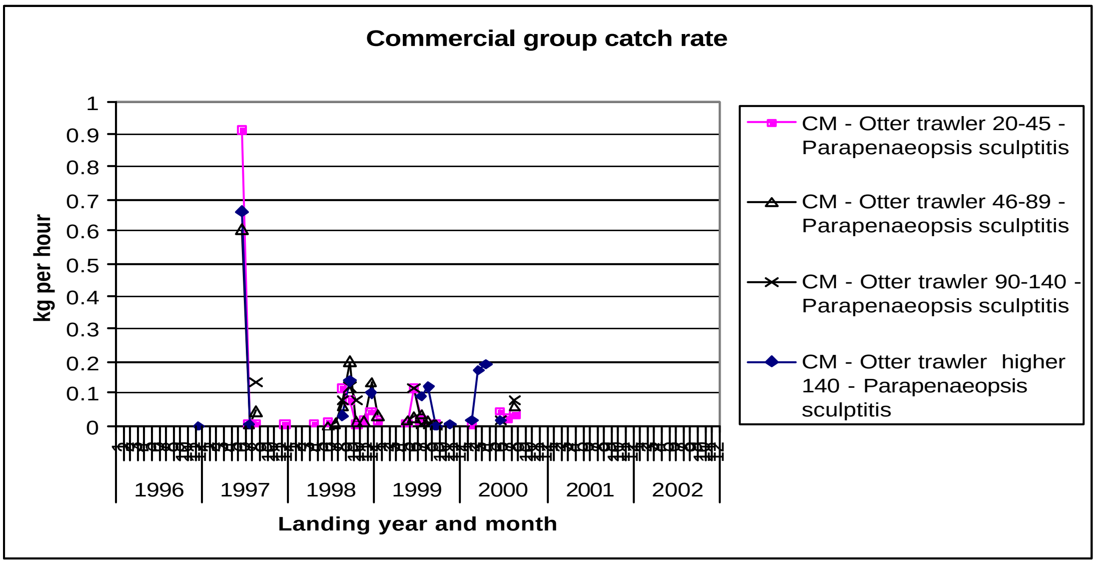



Figure 3.4.38

*Figure 3.4.37-3.4.38:* The cat prawn catches taken during the peak in 1999 and 2000 were almost all sold as the Cat Prawn commercial group (Figure 3.4.37). The enumerator data indicate that the catch rates of the commercial group P*arapenaeopsis sculptitis* (Figure 3.4.38) have always remained low (less than 0.1kg per hour except a few observations in 1997).

Low Value Shrimp

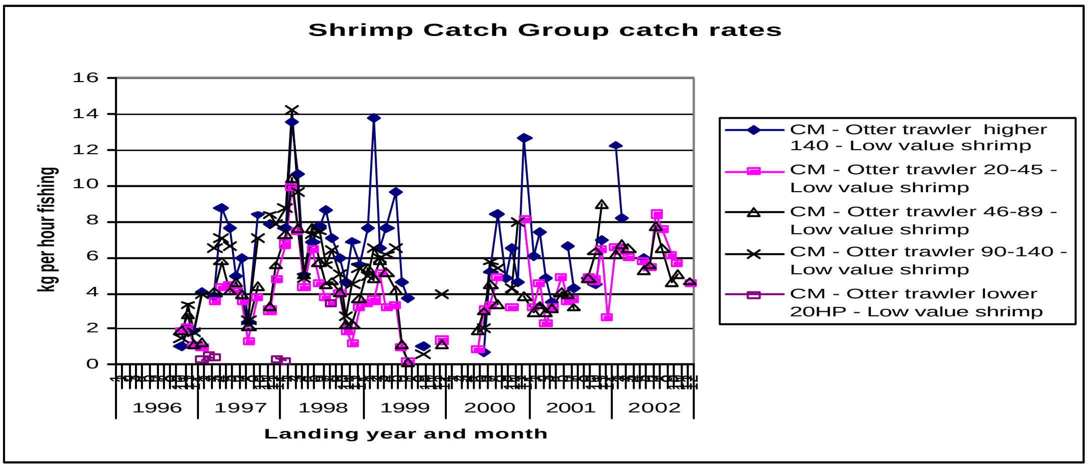



Figure 3.4.39

*Figure 3.4.39:* The catch rates of the Low Value Shrimp fluctuated mostly between 2 and 8kg/hour for all fleets except the HP<20 having catch rates always below 2kg/hour. The larger vessels had peak catch rates as high as 14kg/hour for 1 or two months by the end or in the beginning of a calendar year. During second half of 1999 and first half of 2000 the Low Value Shrimp catch group was almost entirely absent from the catches.

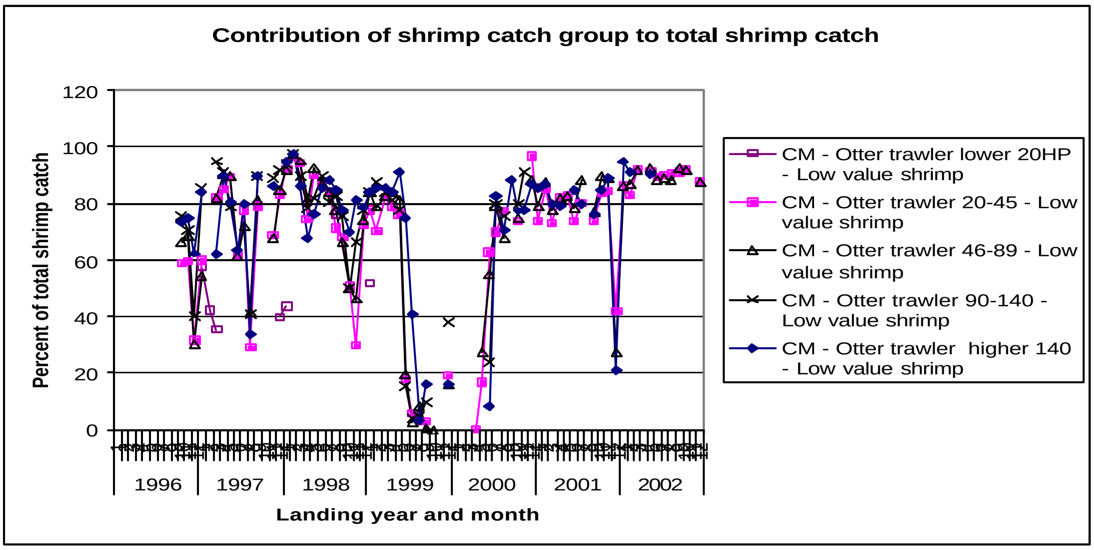



Figure 3.4.40

*Figure 3.4.40:* Since 1997 the Low Value Shrimp contribution to total shrimp catches has been in counter phase with the Cat Prawn contribution. The Low Value Shrimp comprised between 80 and 90% of total shrimp catches except during the period from mid 1999 to mid 2000 where Cat Prawns dominated the catches.

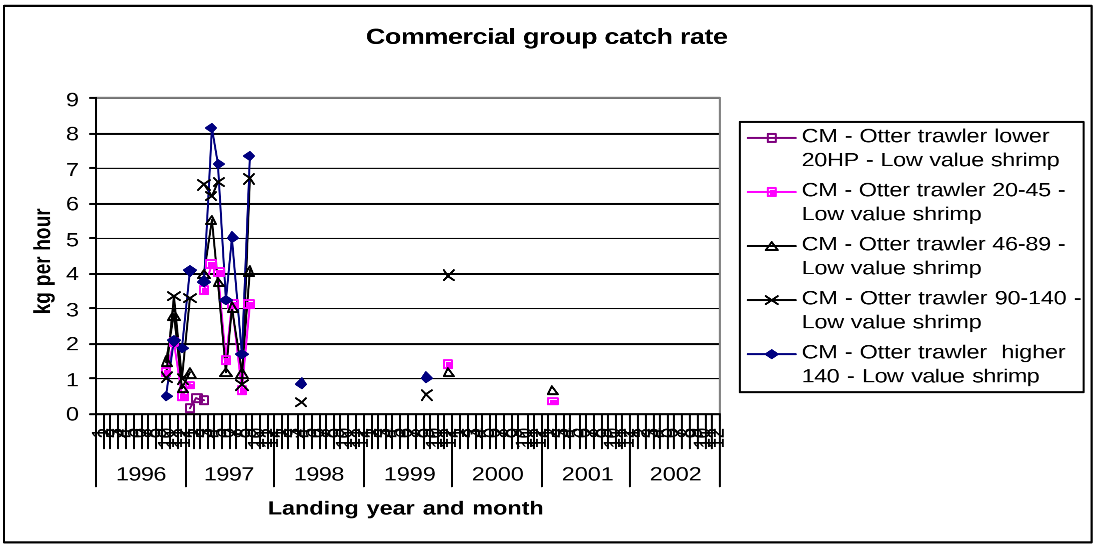



Figure 3.4.41

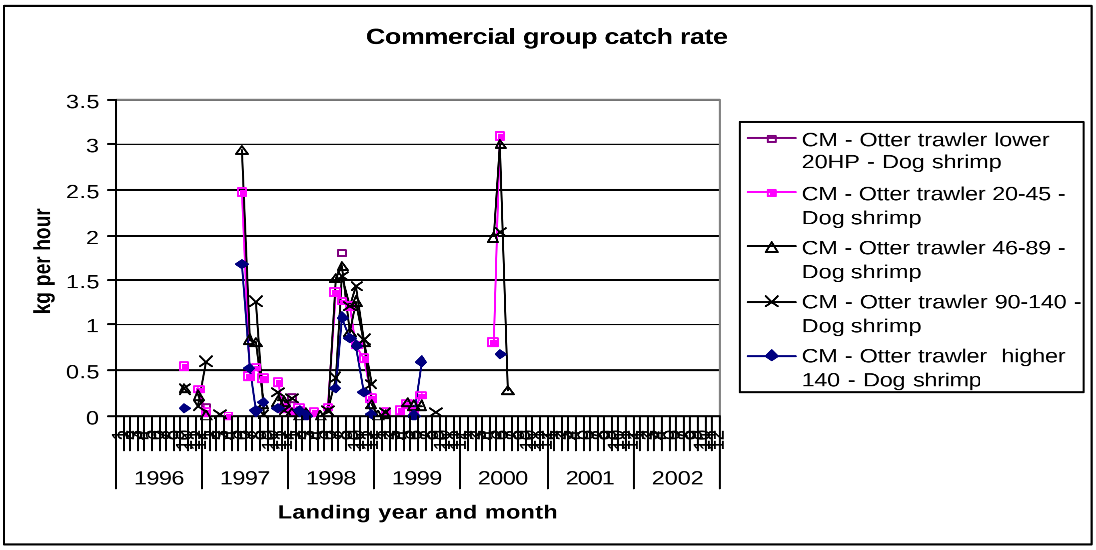



Figure 3.4.42

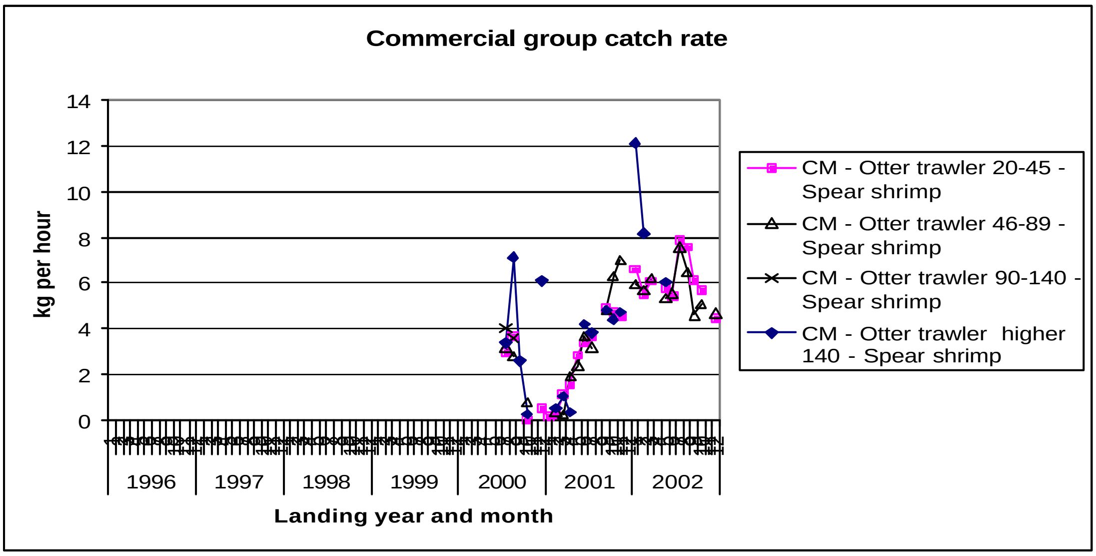



Figure 3.4.43

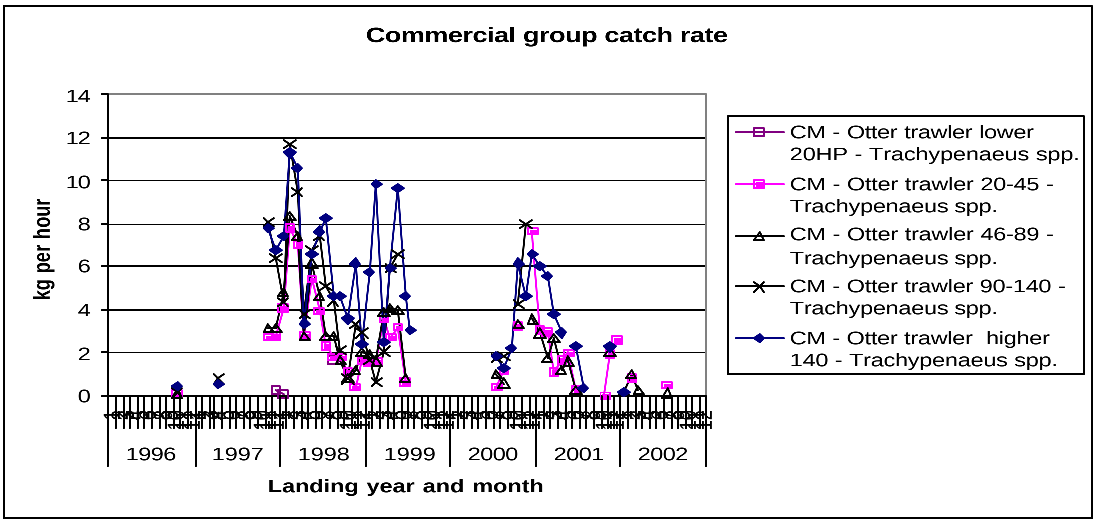



Figure 3.4.44

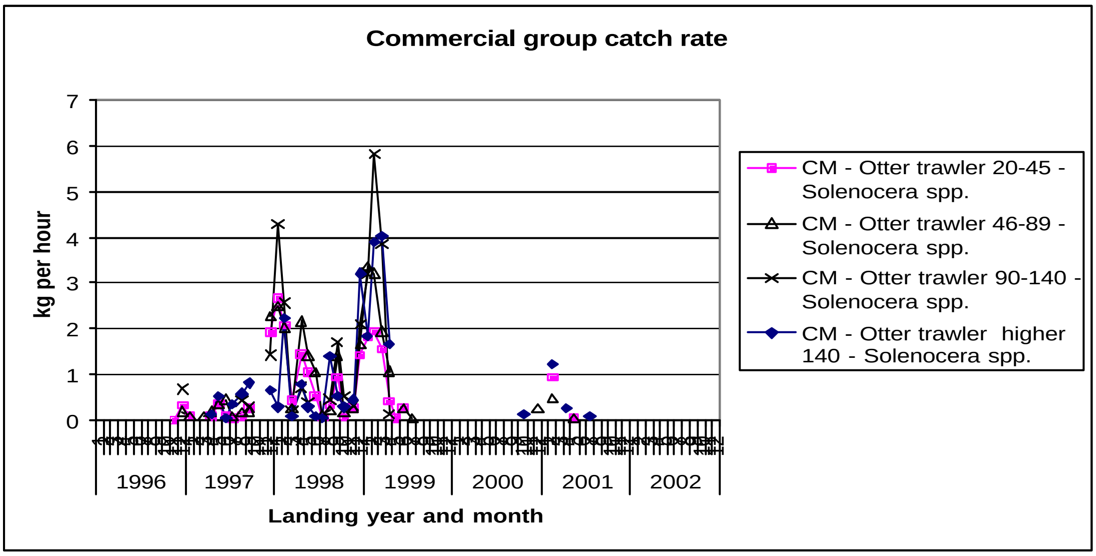



Figure 3.4.45

*Figure 3.4.41-3.4.45:* The commercial group composition of the Low Value Shrimp has changed considerably from 1996 to 2002. Until middle of 1997 the Low Value Shrimp commercial group was the only one. From end of 1997 to middle of 1999 the Trachypenaeus commercial group was dominant although with some Solenocera and a little dog shrimp present. From middle of 2000 almost all Low Value shrimp belonged to the Tracheypenaeus commercial group.

Pink Prawn

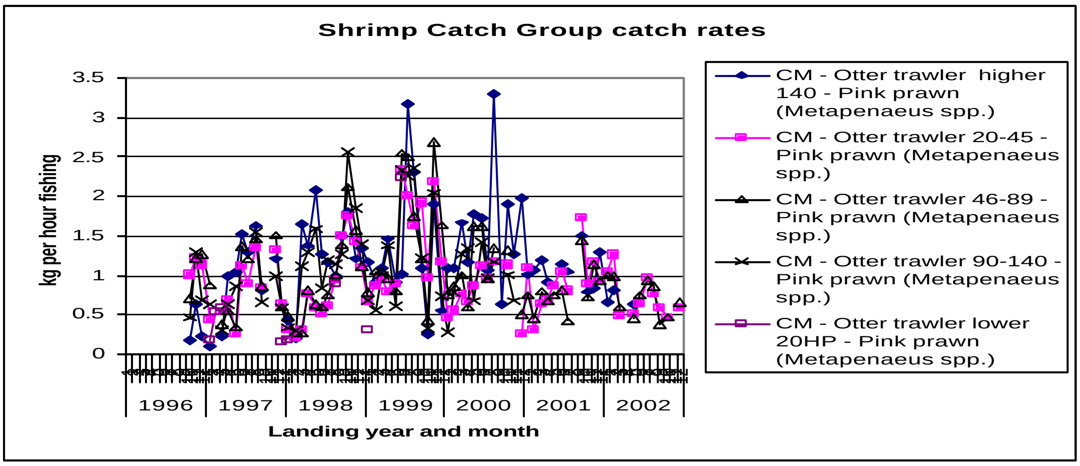



Figure 3.4.46

*Figure 3.4.46:* The average Pink Prawn catch rates increased from about 0.5kg/hour in 1997 (fluctuations between 0.25 to 1.25kg/hour) to 1.5kg/hour by end of 1999 (fluctuations from 0.25 to 3kg/hour). After 2000 the average catch rates have declined gradually to 0.5kg/hour. From 1998 to 2000 short periods of very high catch rates were observed. After 2001 no peaks in catch rates are observed.

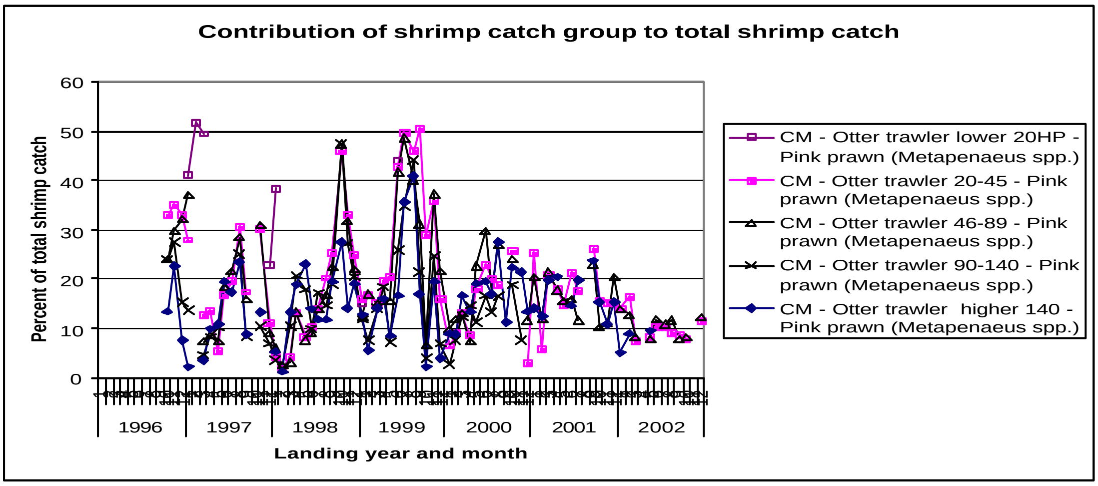



Figure 3.4.47

*Figure 3.4.47:* Pink Prawn contribution to total catches has decreased to about 10% in 2002. During periods with high catch rates in 1998 and 1999 this catch group comprised up to 50% of the total shrimp catches. In 2000 fluctuations between 10 and 30% were common.

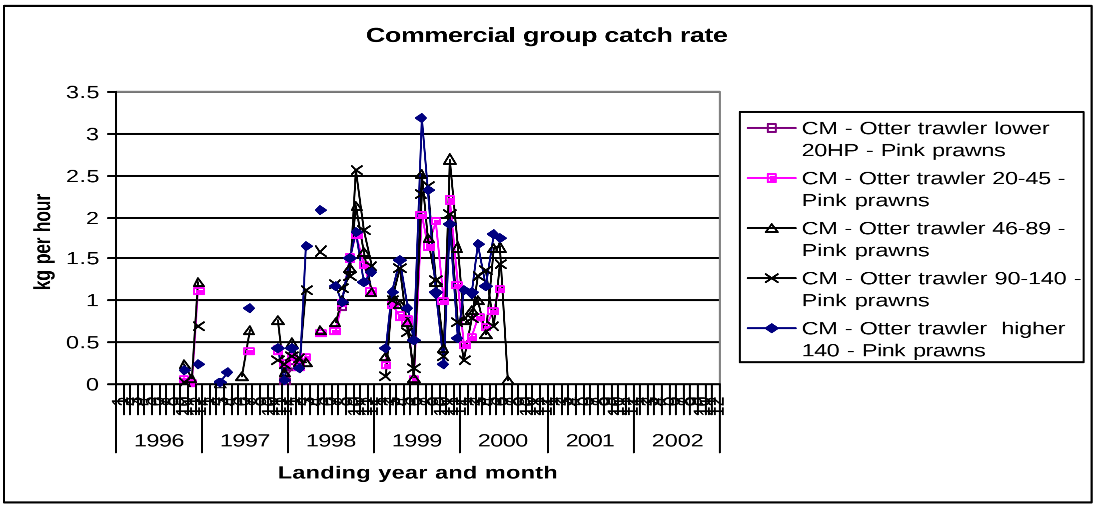



Figure 3.4.48

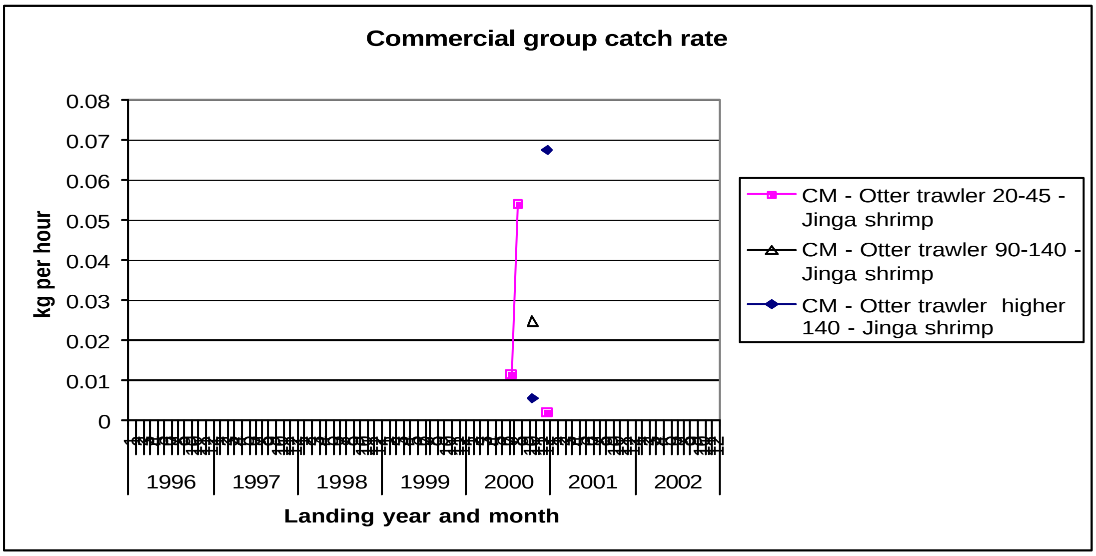



Figure 3.4.49

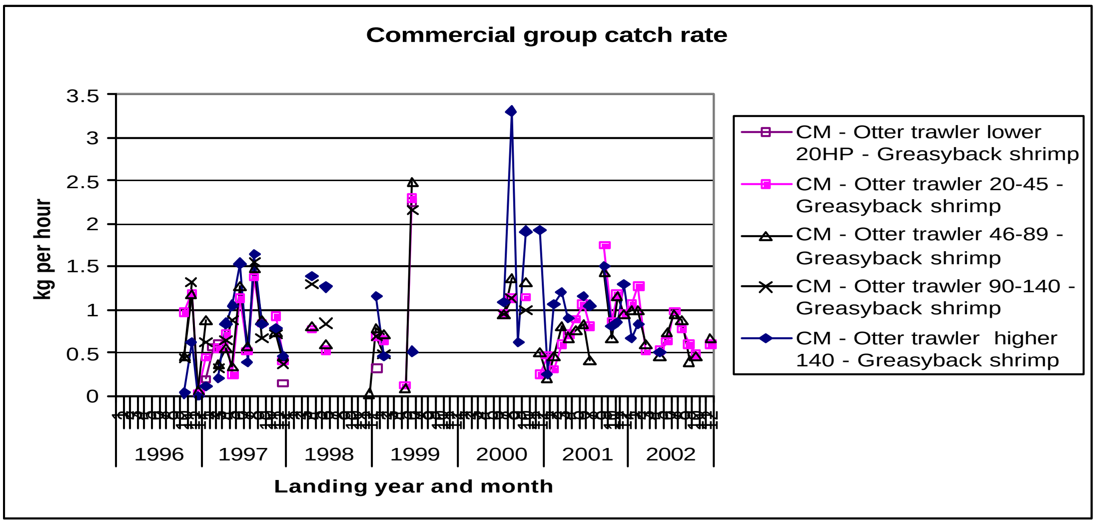



Figure 3.4.50

*Figure 3.4.48-3.4.50:* Before 1998 most of the Pink Prawn belonged to the Greasy Back commercial group having a catch rate between 1 and 1.5kg per hour. From 1998 to middle of 2000 the catch rates of pink prawn increased to about 2 kg per hour and they were sold as Pink Prawn commercial group (Figure 3.4.48). After middle of 2000 the catch rates fluctuated between 0.5 and 1kg per hour and all belonged to the Greasy Back commercial group.

There are no price differences between the Pink Prawn commercial groups.

White Shrimp

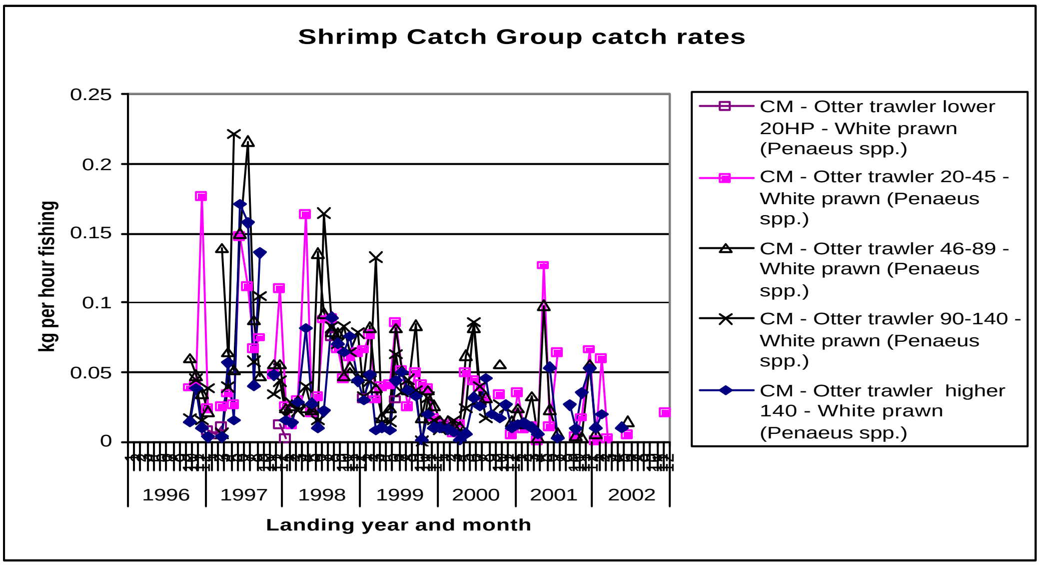



Figure 3.4.51

*Figure 3.4.51:* The average catch rates of the White Shrimp have decreased from about 0.1kg/hour in 1997 to less than 0.025 in 2002. Before 1998 the catch rates fluctuated between 0 and 0.2kg/hour but after 1999 the high peaks are absent.

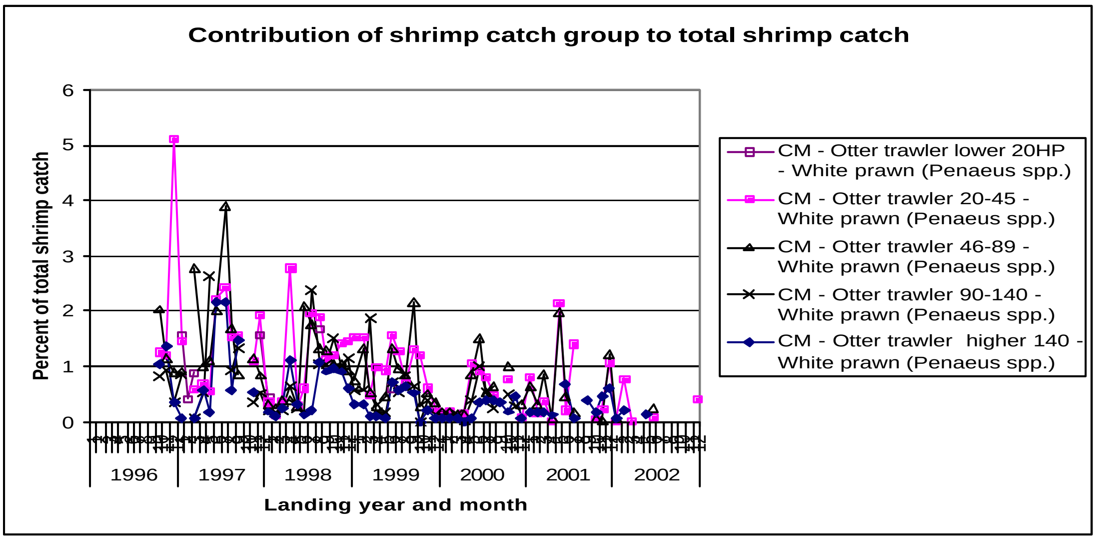



Figure 3.4.52

*Figure 3.4.52:* The contribution of White Prawns to the total shrimp catch rate has decreased from a level between 1 and 2% in 1998 and 1999 to less than 1% from 2000. In 2002 white shrimp was almost absent from the catches.

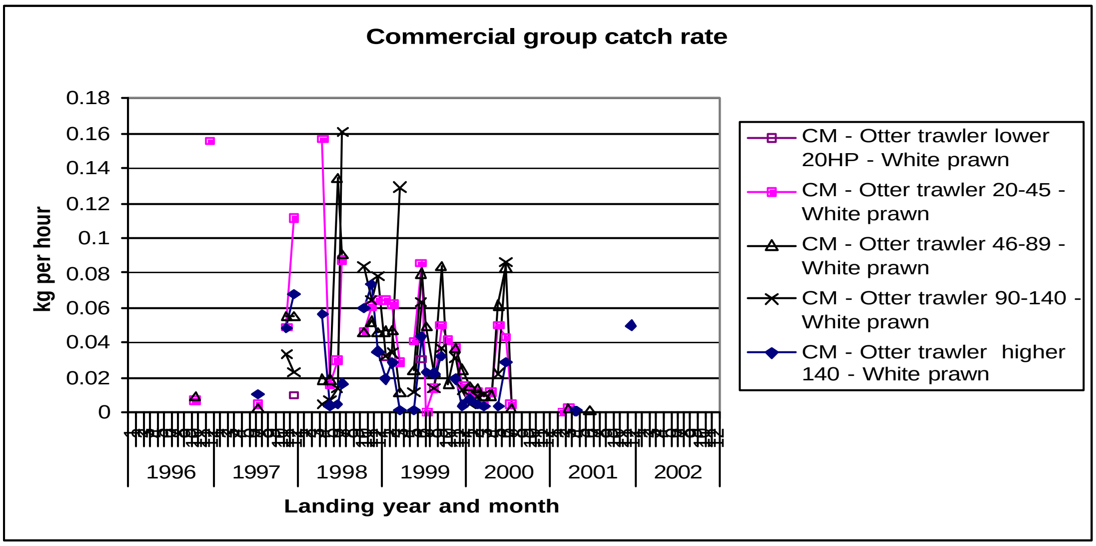



Figure 3.4.53

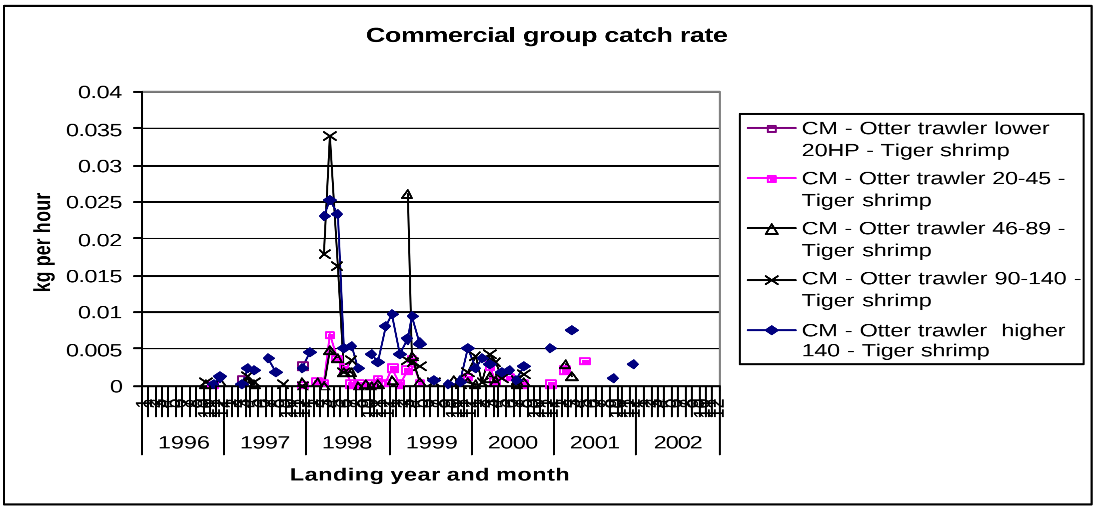



Figure 3.4.54

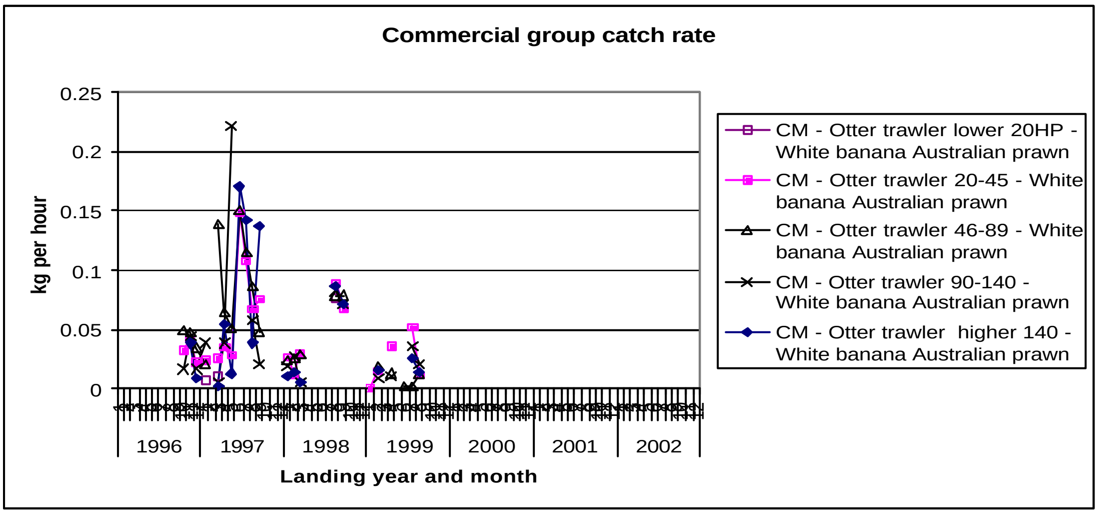



Figure 3.4.55

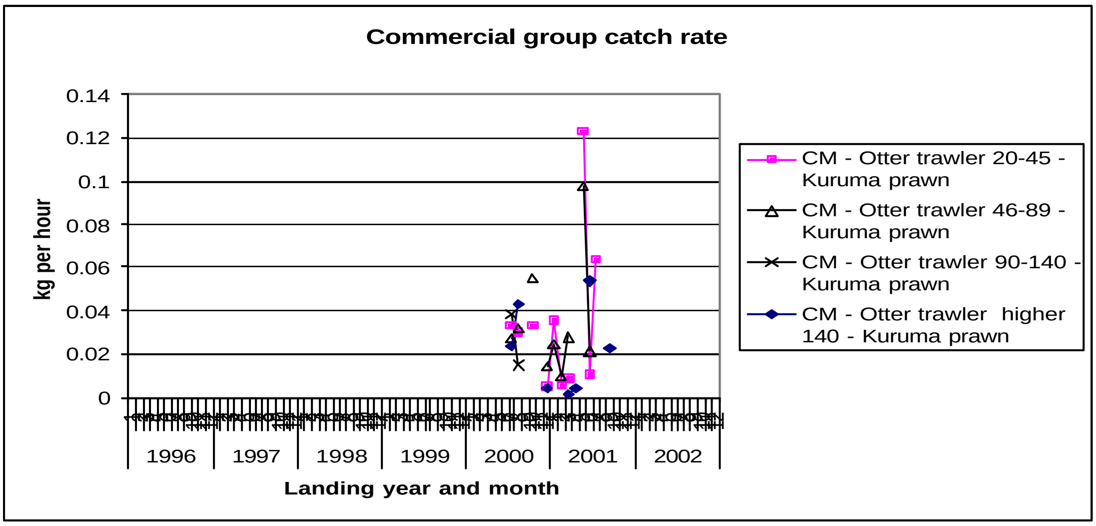



Figure 3.4.56

*Figure 3.4.53-3.4.56:* Until end of 1997 the White Banana commercial group dominated the White Shrimp catches for all fleets (Figure 3.4.55). From 1998 until mid 2000 the White Shrimps were primarily sold as White Prawn commercial group. During this period the catch rates decreased from about 0.08 to virtually 0kg per hour. From mid 2000 Kuruma Prawn was the dominant commercial group with catch rates about 0.02kg/hour. The catch rates of Tiger shrimp has always fluctuated at a very low level (between 0 and 0.005 kg/hour apart from a few observations).

Yellow Shrimp

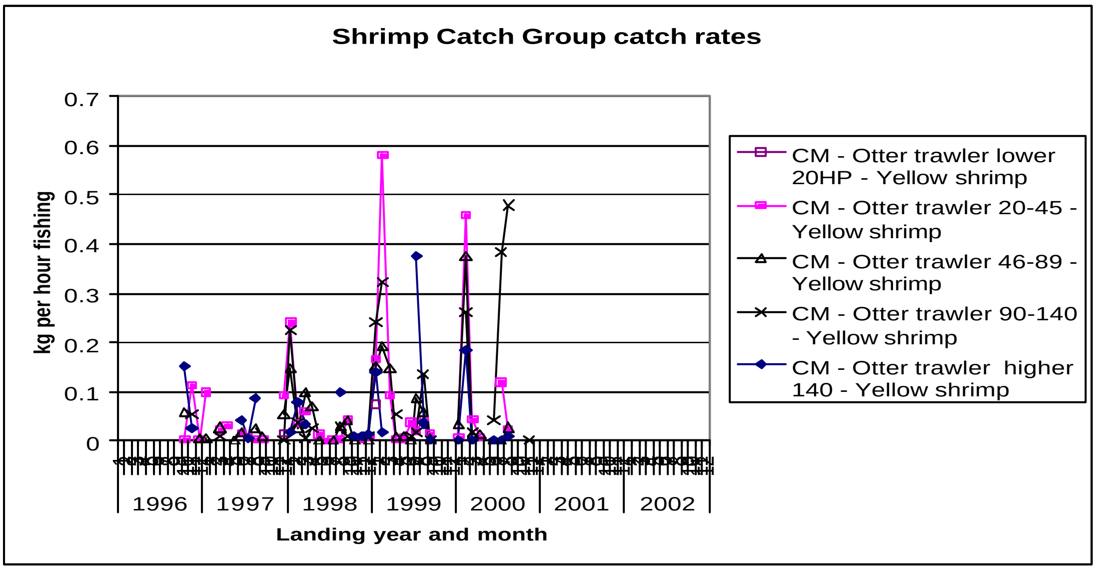



Figure 3.4.57

*Figure 3.4.57:* Yellow Shrimp catch rates have been low (less than 0.1kg/hour) from 1996 through 2000 except short periods by the turn of the years where they have been up to 0.5kg/hour. Yellow Shrimp have been absent from the landings since beginning of 2001.

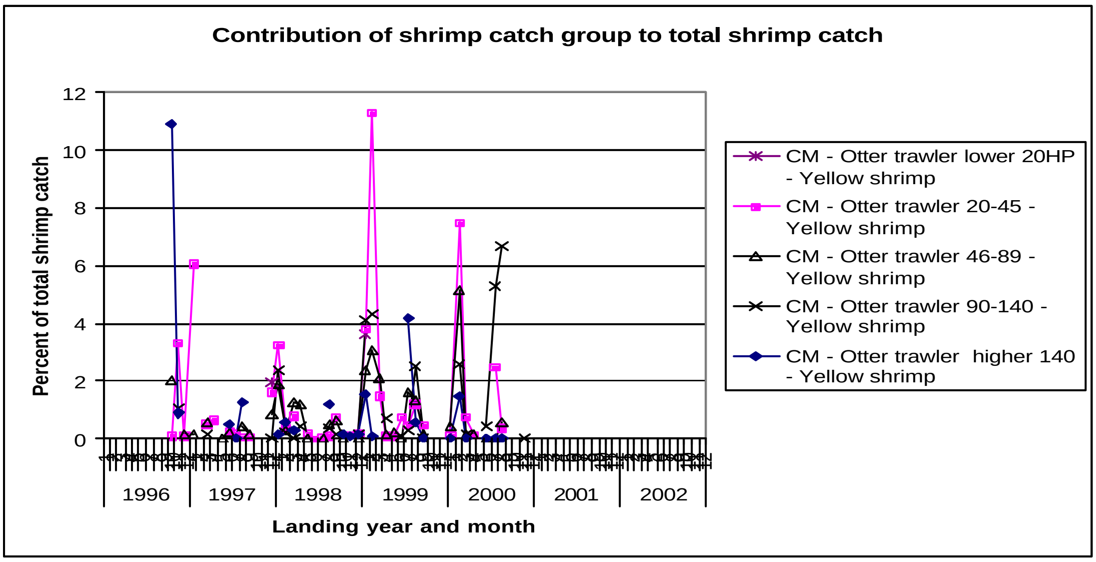



Figure 3.4.58

*Figure 3.4.58:* The contribution of Yellow Shrimp to total catches has been at a very low level (few percent) throughout the entire period except during the short periods of peaks.

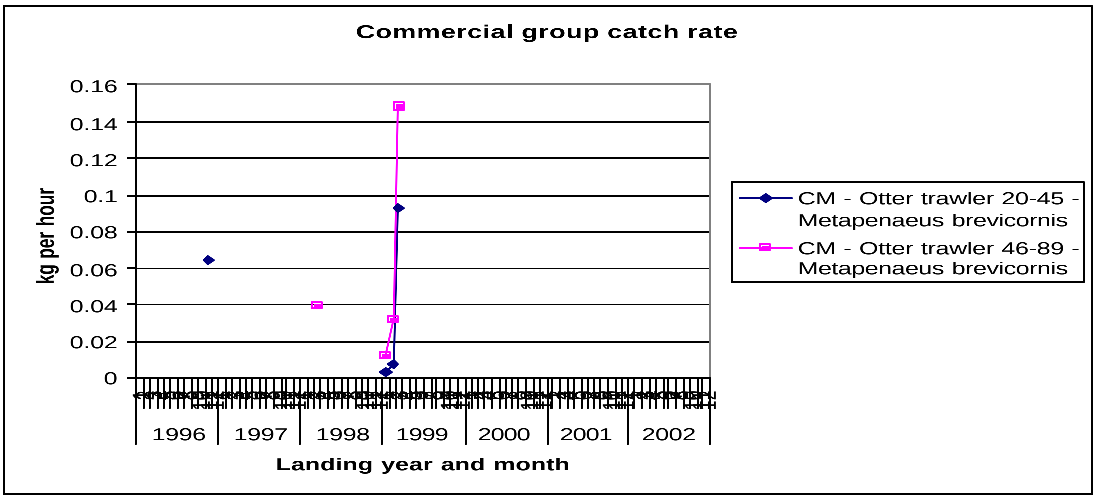



Figure 3.4.59

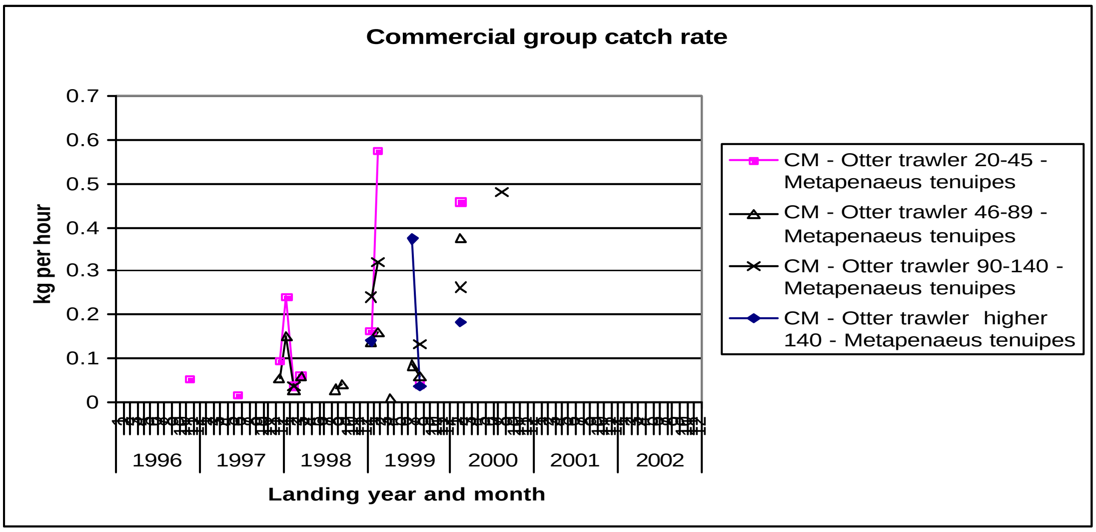



Figure 3.4.60

*Figure 3.4.59-3.4.60: Metapenaeus tenuipes* was the only commercial group in the Yellow Shrimp catch group (Figure 3.4.60) except by the turn of year 1998/1999 when *M. brevicornis* was present in a few catches (Figure 3.4.59).

### *3.4.5 Scientific trawl Survey*

A scientific trawl survey programme covering the depth zones from 20-200 m in the SE and SW offshore areas was initiated in 2000 with support from ALMRV II. Within this programme, two surveys (one in each monsoon season) with 48 fixed stations in SE and 16 in SW areas were carried out in 2000. In 2002 one survey was carried out during the SW monsoon season and in 2003 there was one during the NE monsoon season. In addition to the offshore surveys, 4 shrimp surveys covering the shallow waters of Ca Mau peninsular were conducted in the period 2001-2002.

The objectives of the surveys were to provide data for the fishery ecosystem and resources profiles for the management area through the indicators as below:

?? Species composition for biodiversity index by area and depth strata
?? Catch rates for single species and multi species complex by area, depth strata
?? Catch rates by ecological groups
?? Distribution of catch rates over the surveyed area
?? Density, biomass and production for single species and multi species complex
?? Length frequency data for selected species
?? Length at mature for selected species

| Area | Period | CPUE kg/h | CV (%) | Density kg/km$^2$ | Species composition (pct) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Penaeus (white) | Metapenaeus (pink) | Parapenaeopsis (cat) | Metaphenaeopis |
| SW | 1975-85 | 8.23 | | 168 | 34.5 | 38.0 | 2.0 | 25.5 |
| | 1993-95 | 6.45 | | 131 | 7.0 | 10.2 | 12.2 | 70.7 |
| | 2001 | 4.48 | 76.6 | 119 | 0.5 | 10.9 | 25.0 | 63.6 |
| SE | 2001 | 2.73 | 89.4 | 63 | 0 | 6.1 | 10.6 | 83.4 |

***Research project data***

To support the enumerator data collection programme, a research project was initiated with the objective to evaluate the species composition and length frequencies of the commercial shrimp groups with mixed species.

*Length distributions*

***Bac Leu***

Only trawl data are available from Bac Leu.

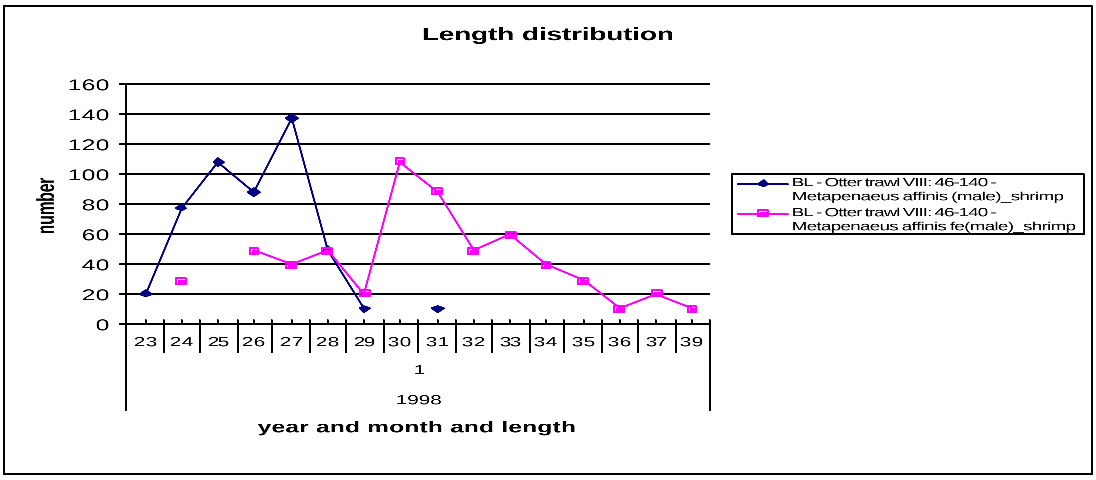



Figure 3.4.61

*Figure 3.4.61:* The only length distribution available from Bac Leu is Metapenaeus affinis, January 1998. The males have a modal length at 27mm and the females at 30mm.

***Ca Mau***

Data from both Otter trawl (Figure 3.4.62-3.4.87) and push net (Figure 3.4.88-3.4.92) catches are available.

Otter trawl

Cat shrimps:

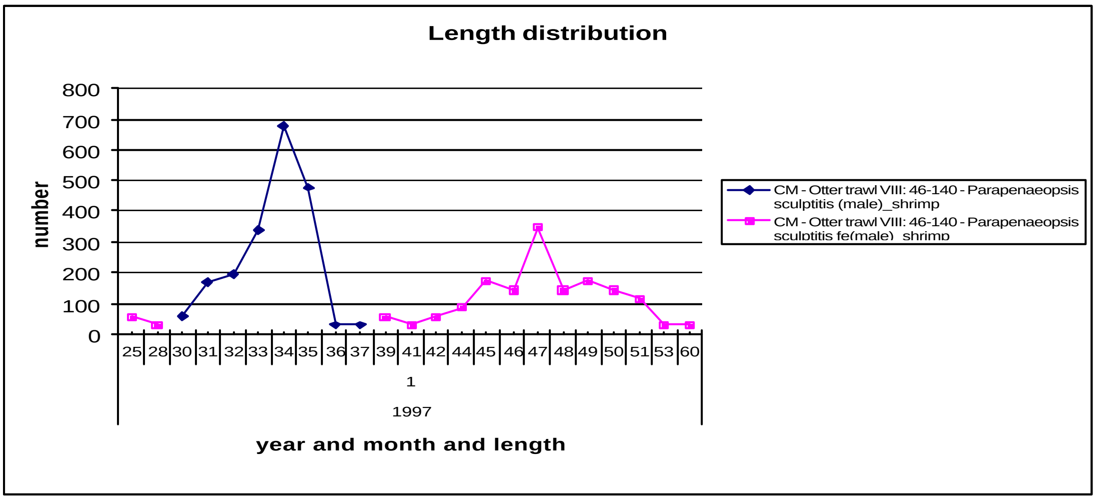



Figure 3.4.62

*Figure 3.4.62:* Only one sample from January 1997 is available. The Modal length for Parapenaeopsis sculptitis is about 34mm for male and 47mm for female.

Pink Shrimp:

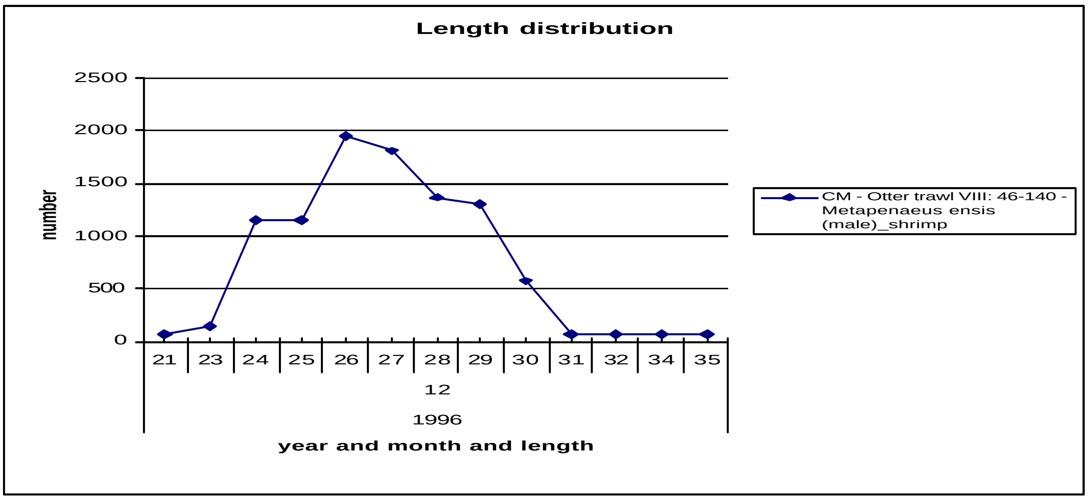



Figure 3.4.63

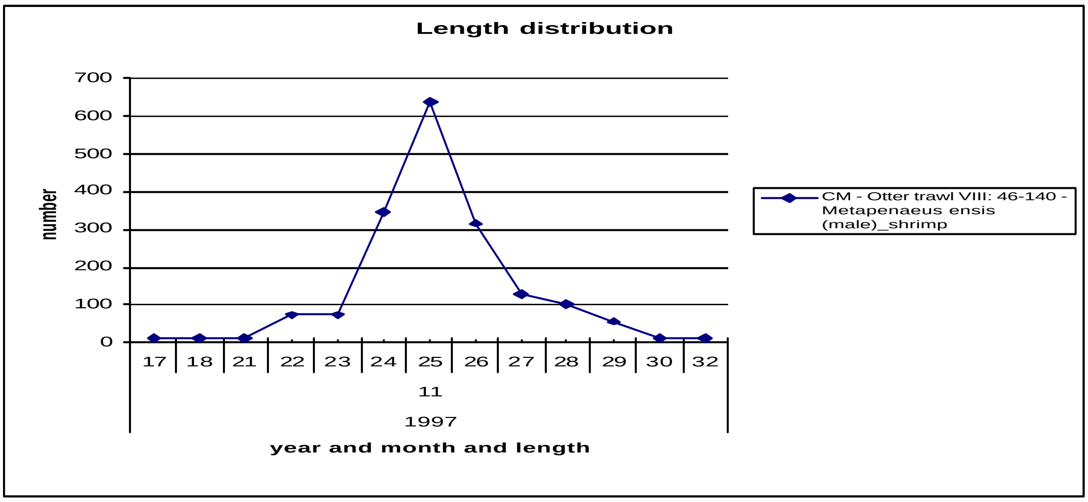



Figure 3.4.64

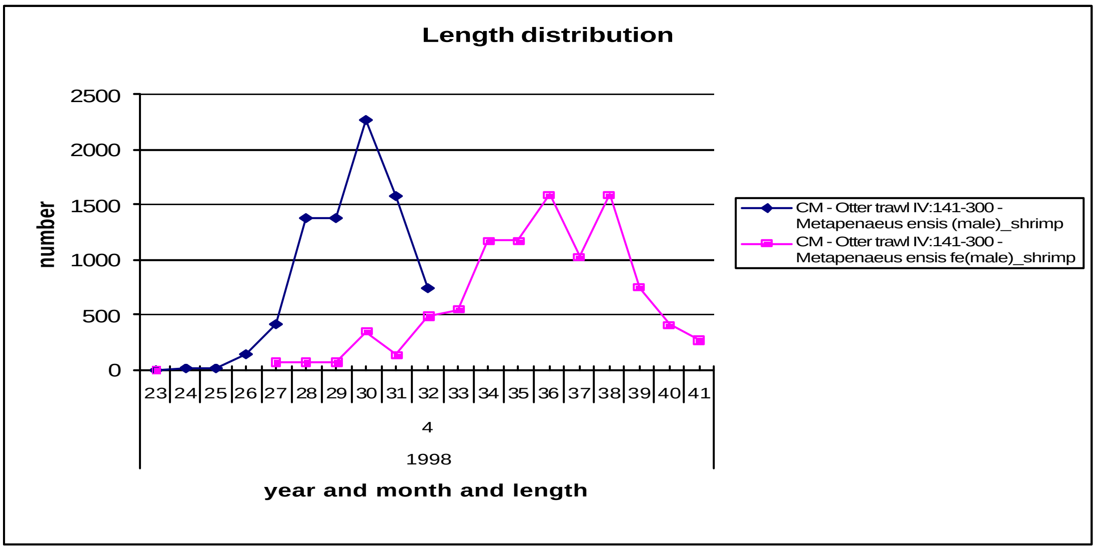



Figure 3.4.65

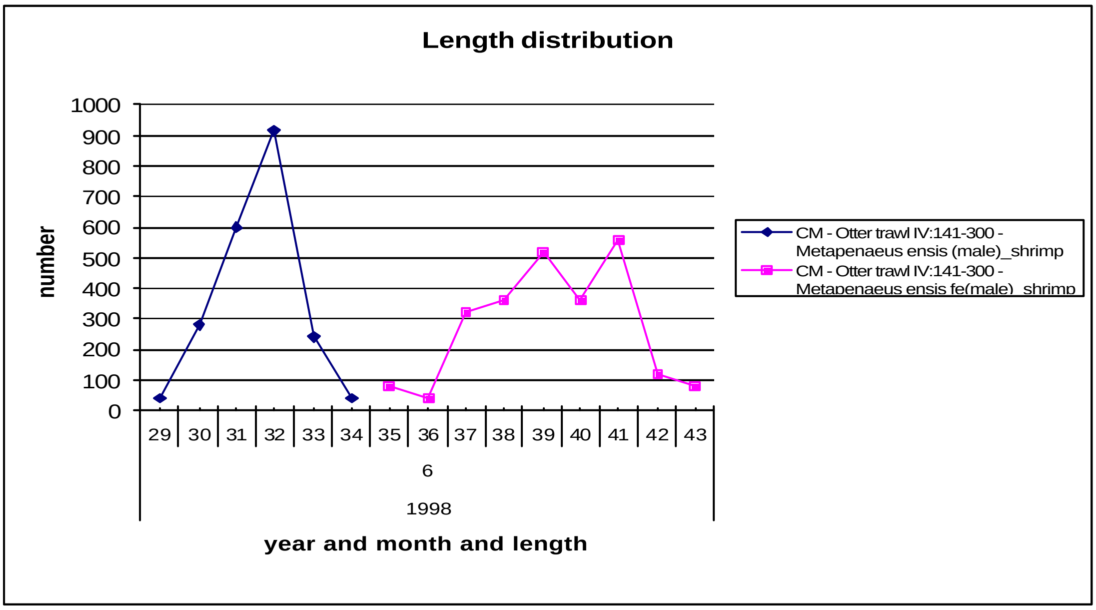



Figure 3.4.66

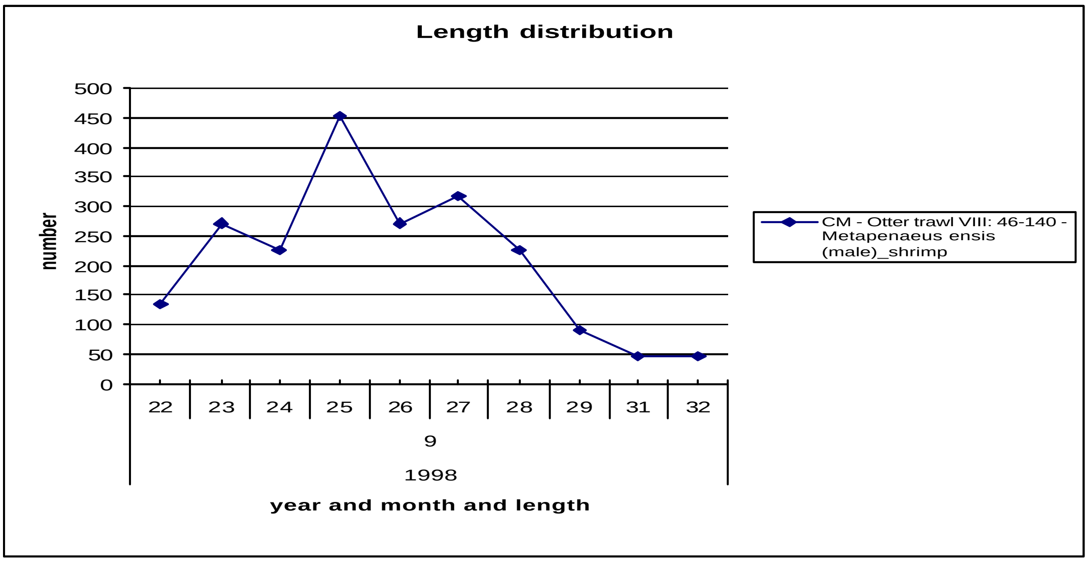



Figure 3.4.67

*Figure 3.4.63-3.4.67:* The average size for male *Metapenaeus ensis* is significantly smaller than for females. In average *Metapenaeus ensis* (data from males only) seem to be larger in middle of calendar year than in beginning and end of calendar year.

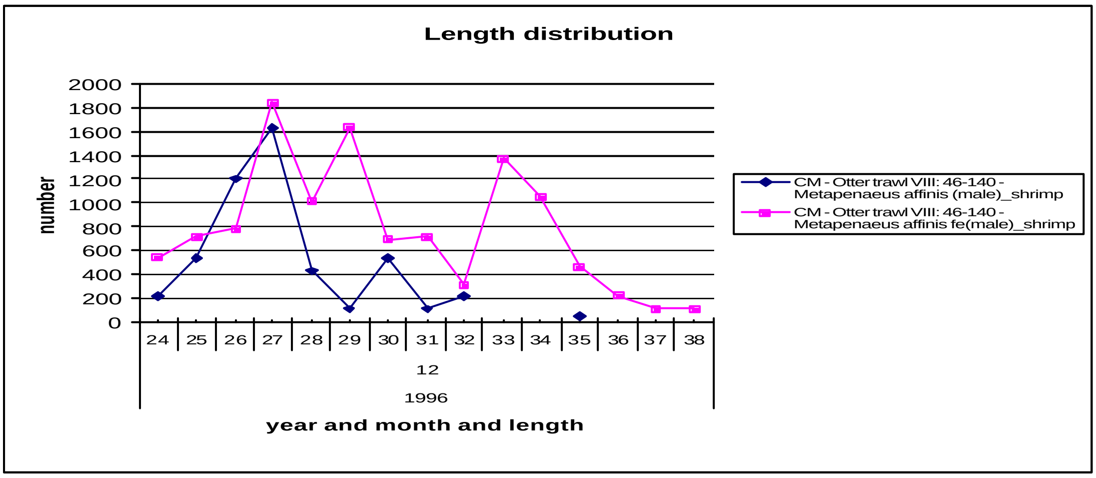



Figure 3.4.68

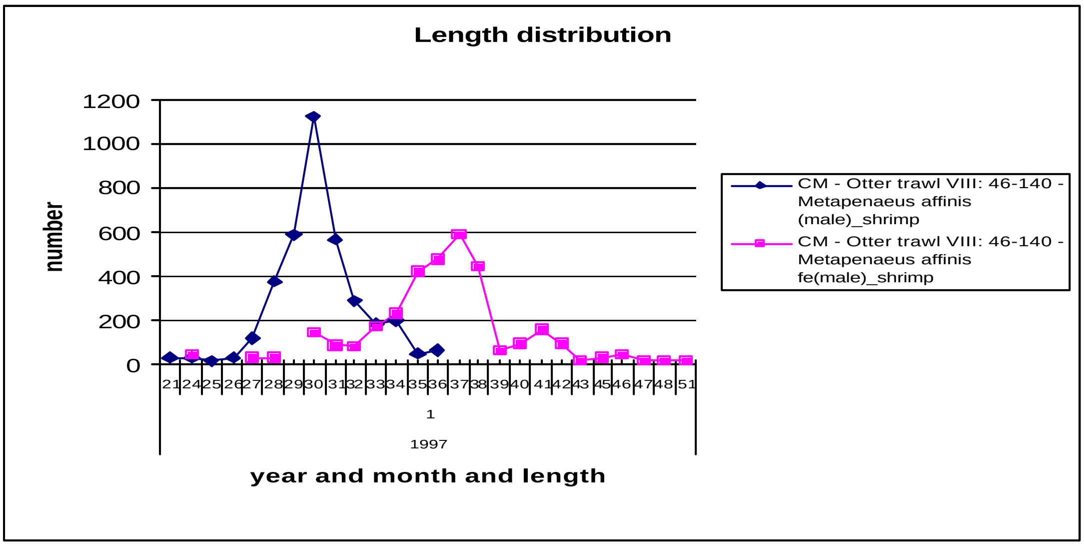



Figure 3.4.69

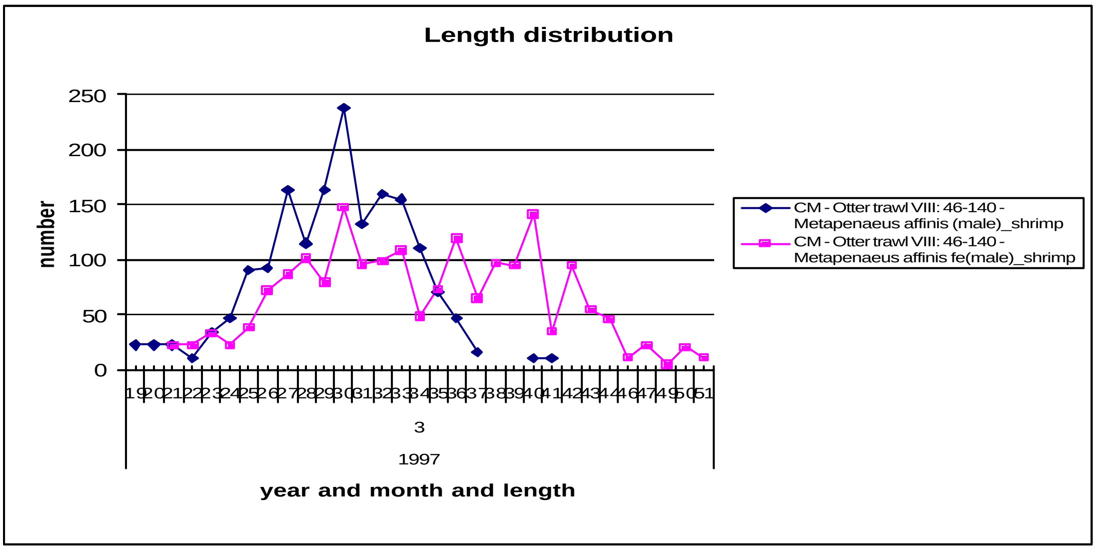



Figure 3.4.70

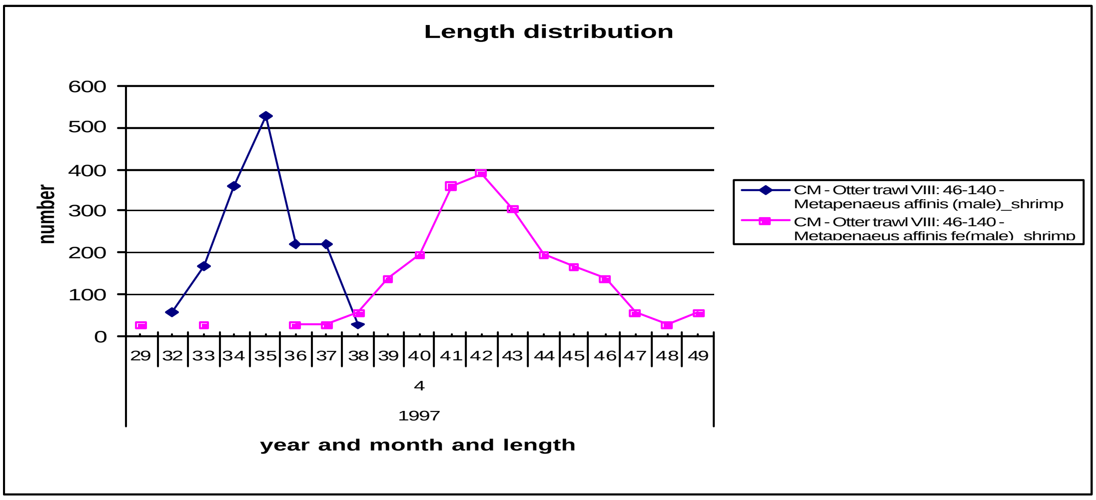



Figure 3.4.71

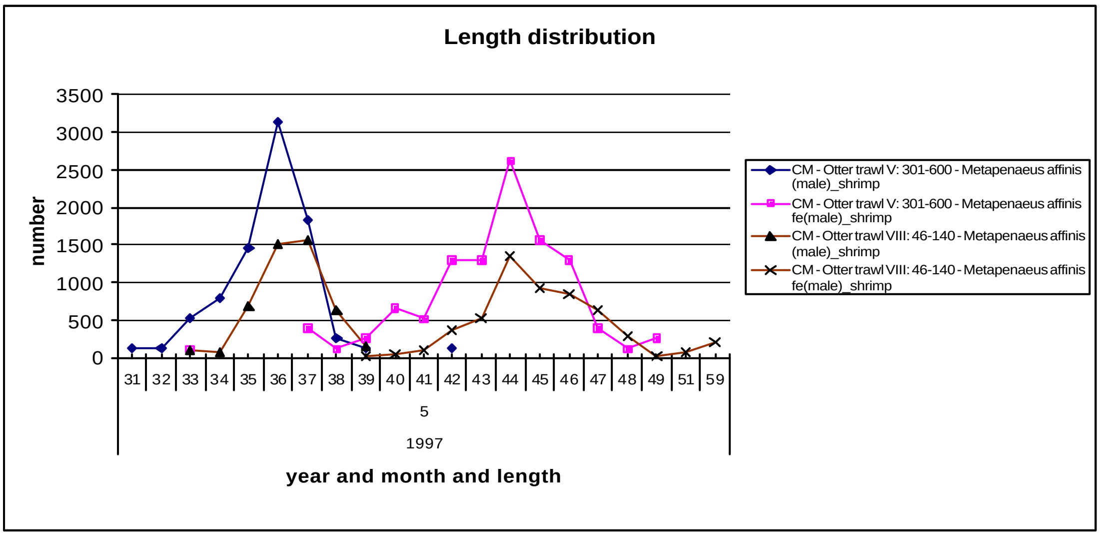



Figure 3.4.72

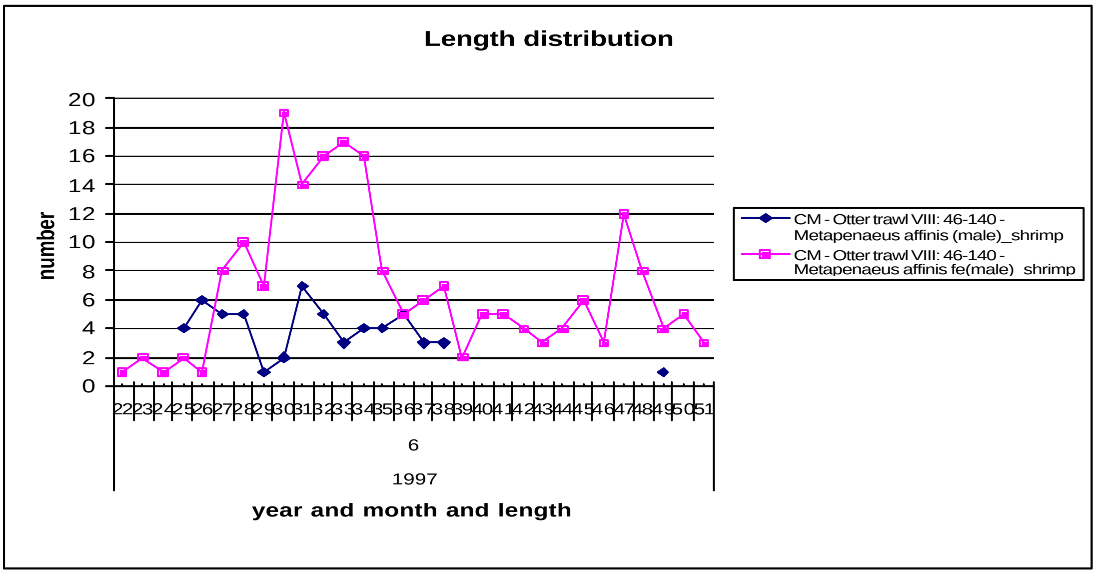



Figure 3.4.73

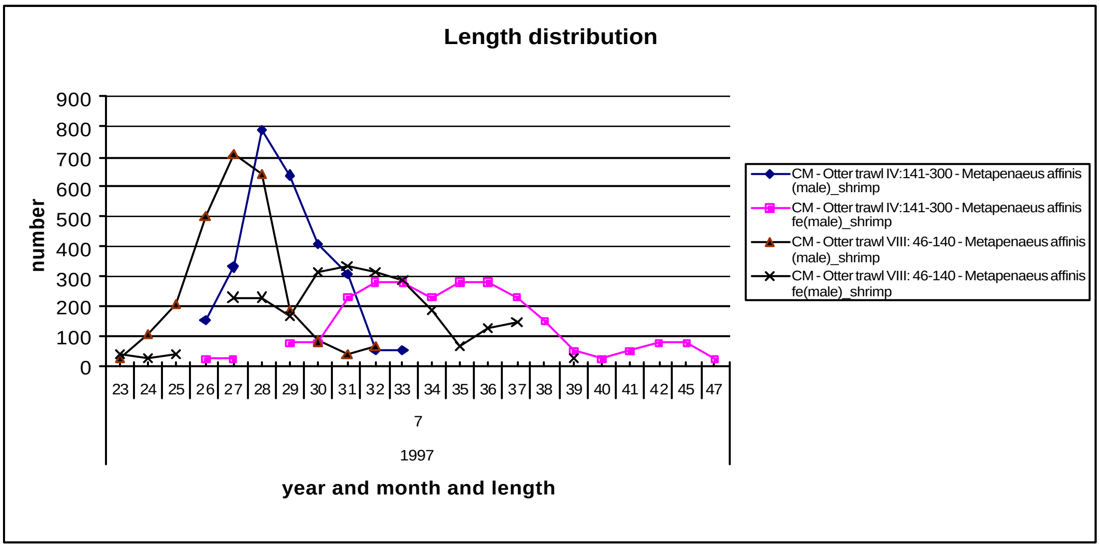



Figure 3.4.74

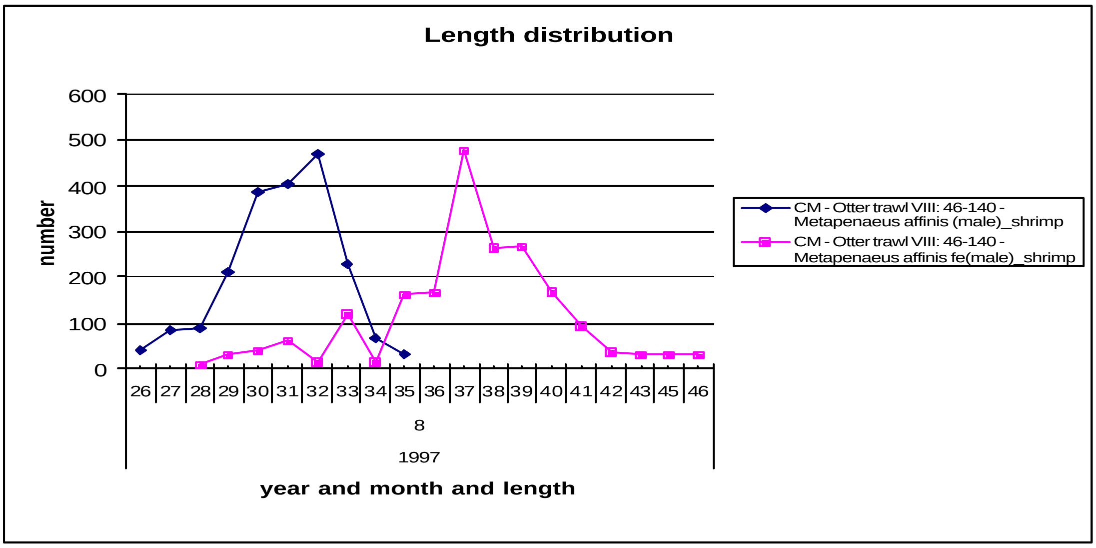



Figure 3.4.75

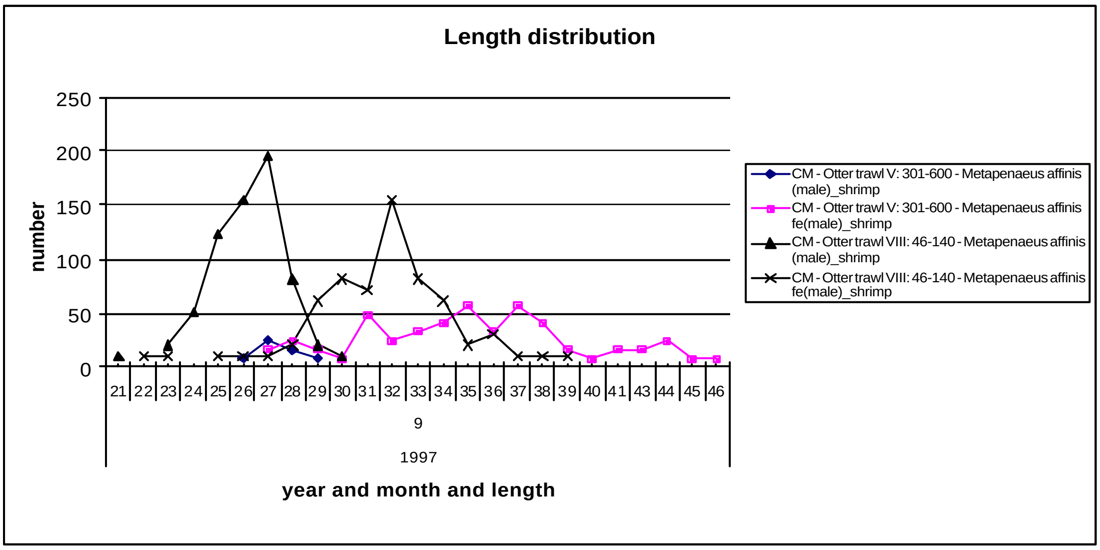



Figure 3.4.76

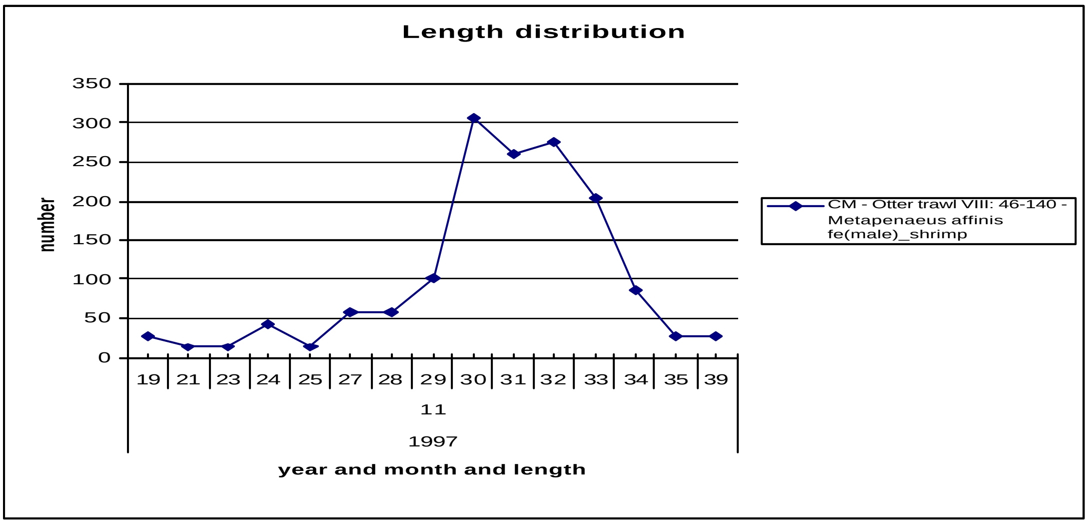



Figure 3.4.77

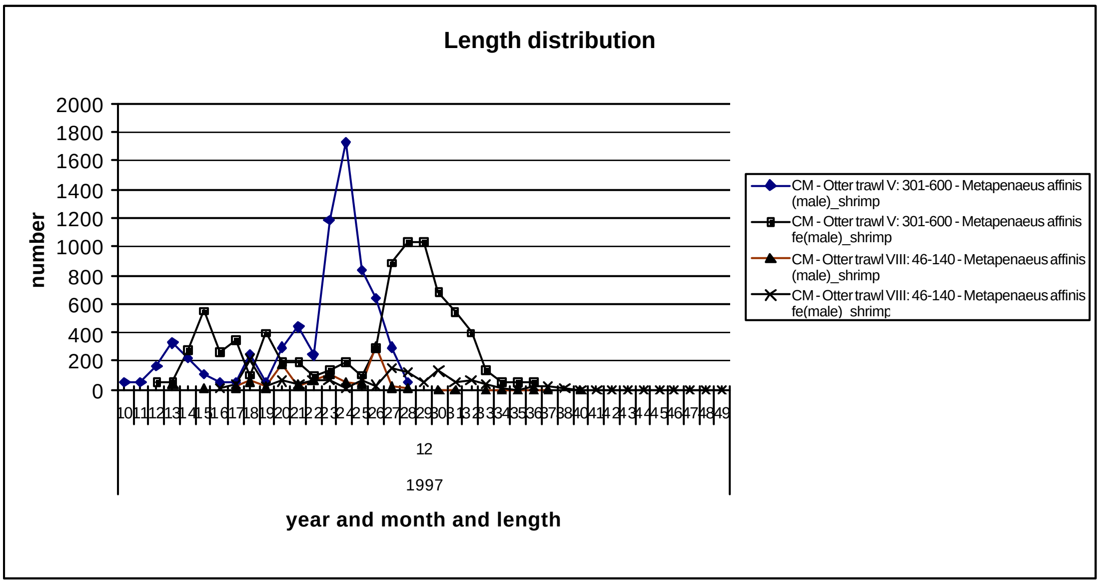



Figure 3.4.78

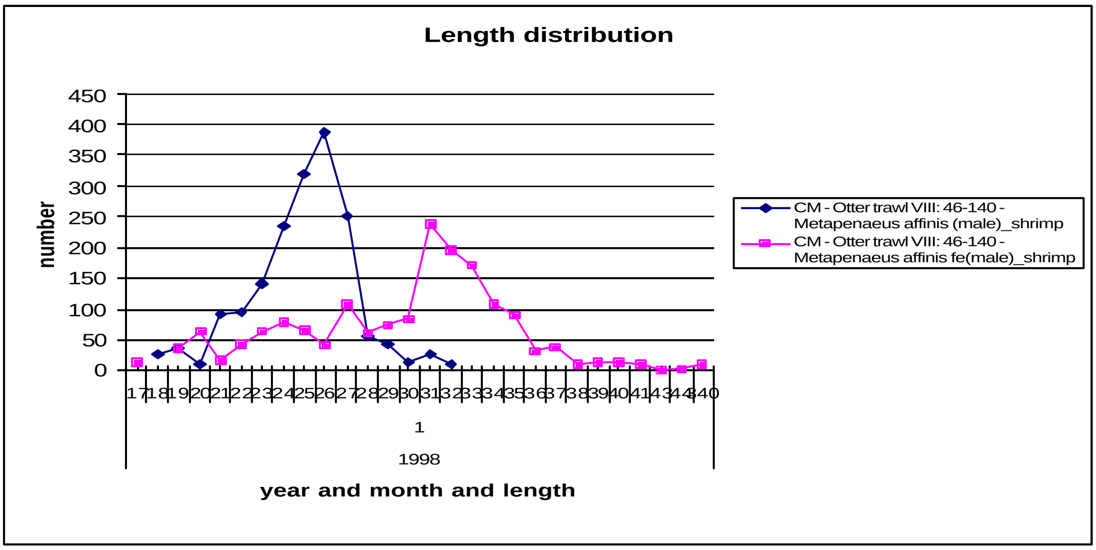



Figure 3.4.79

*Figure 3.4.68-3.4.79:* The average size for male *Metapenaeus affinis* is significantly smaller that for females. In average *Metapenaeus affinis* males and females are larger in middle of calendar year than in beginning and end of calendar year. From Figure 3.4.74 and 3.4.76 it appears that the average size of *Metapenaeus affinis* is dependant on vessel size, being larger in catches of the larger trawlers.

White shrimp:

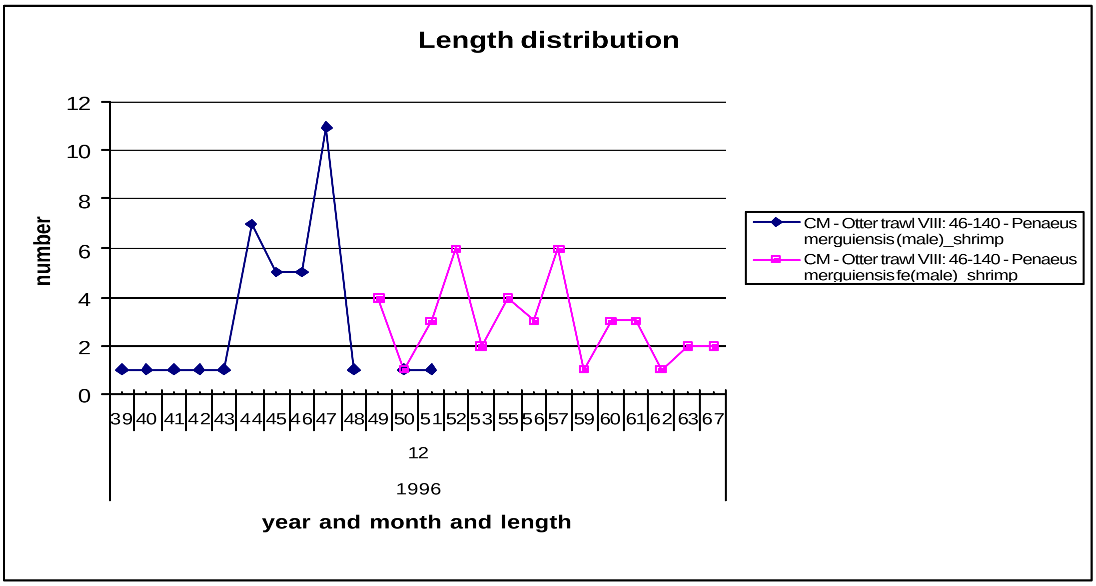



Figure 3.4.80

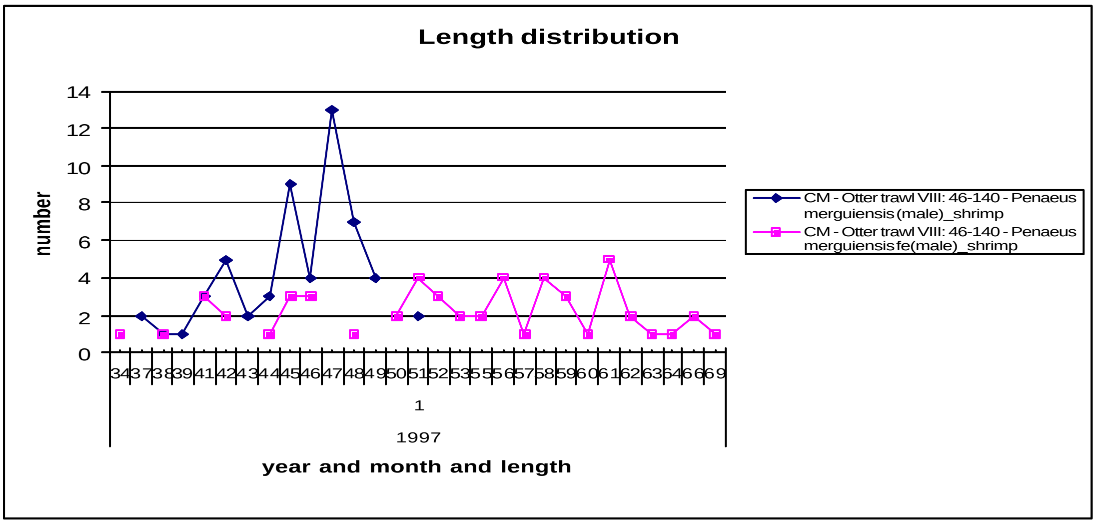



Figure 3.4.81

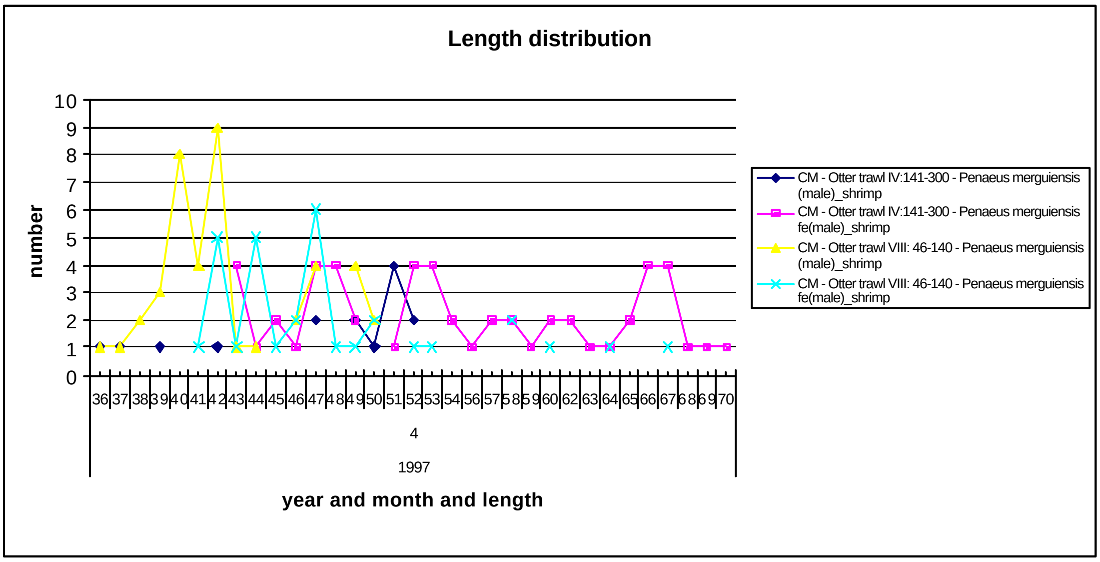



Figure 3.4.82

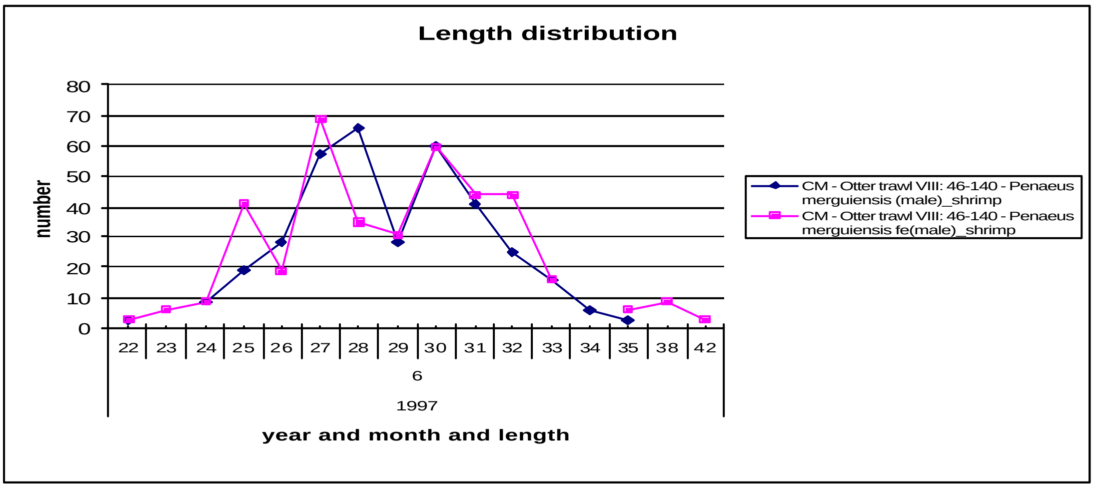



Figure 3.4.83

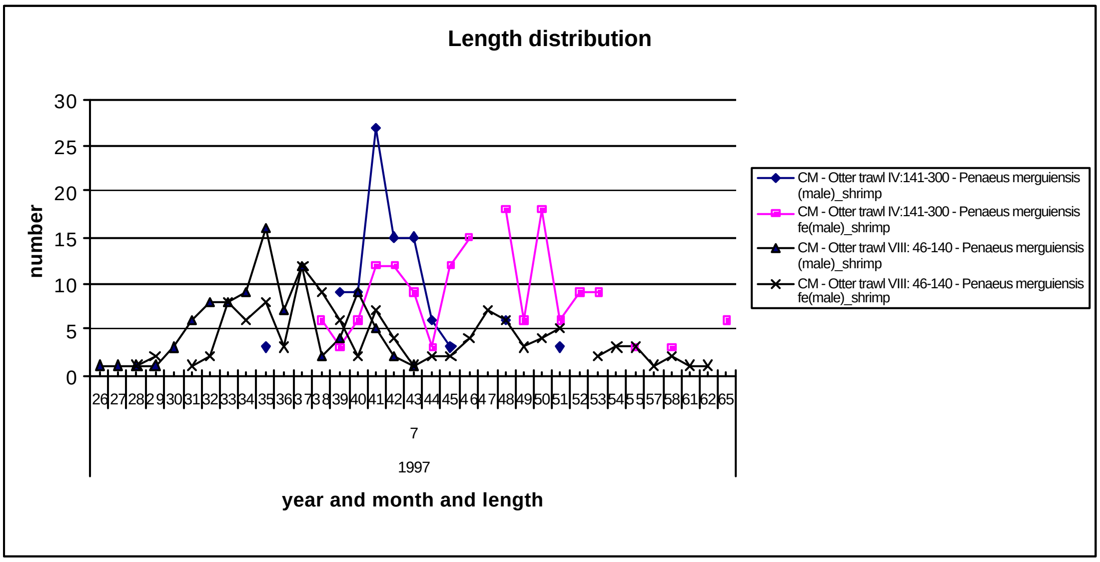



Figure 3.4.84

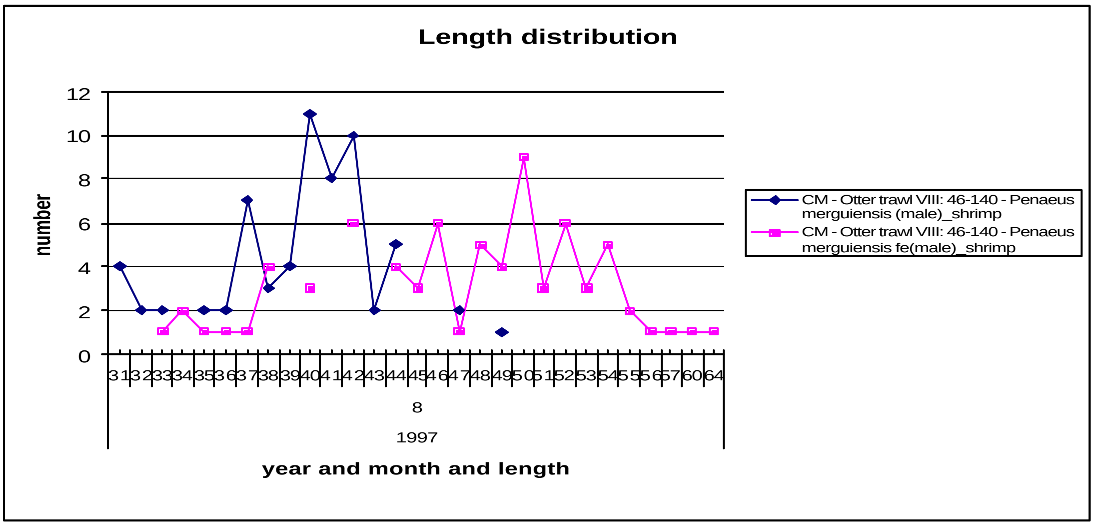



Figure 3.4.85

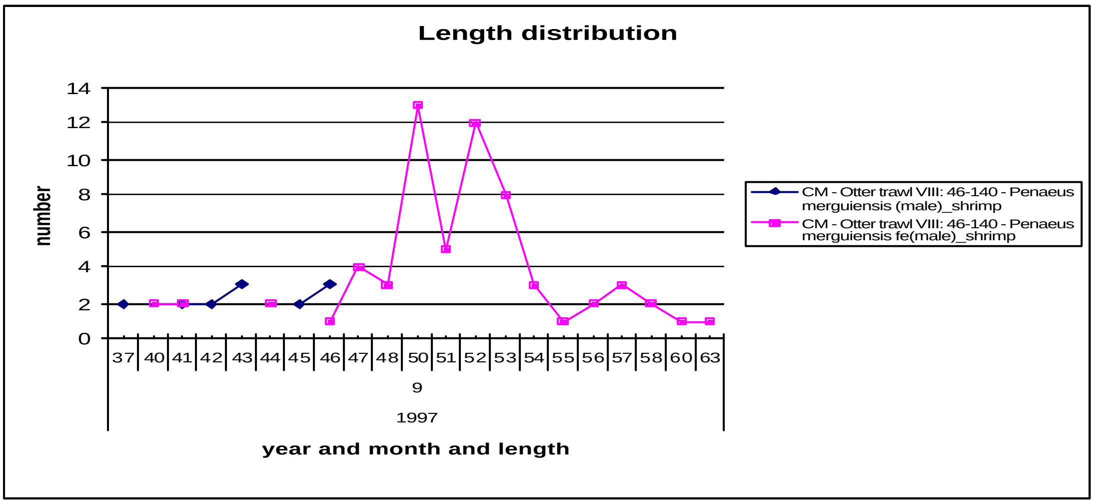



Figure 3.4.86

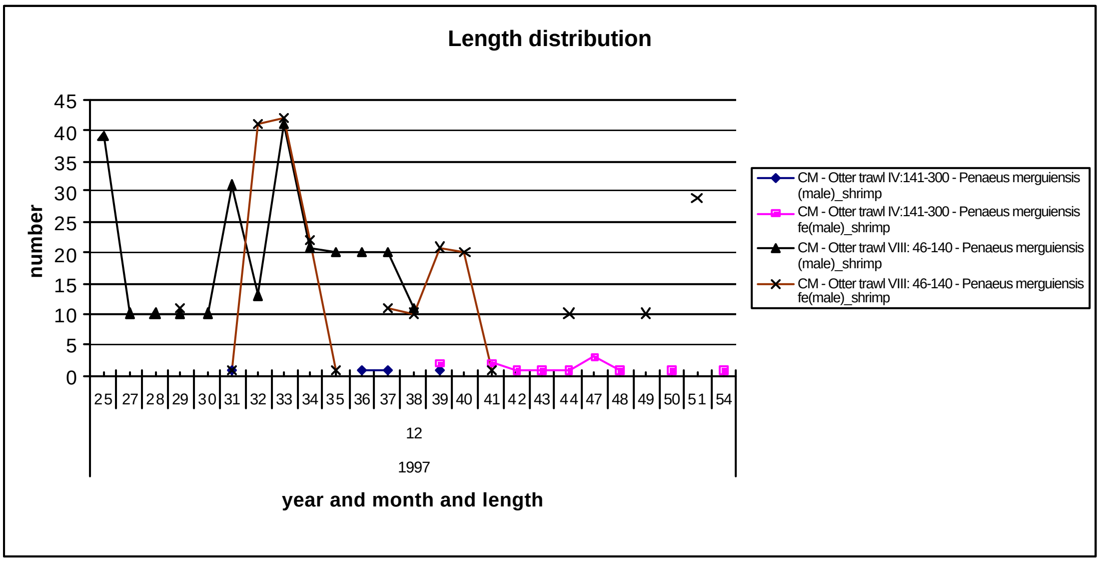



Figure 3.4.87

*Figure 3.4.80-3.4.87:* Often the samples of *Penaeus merguensis* are so small that it is difficult to recognize the size distributions. Females tend to be larger than males.

Push net data

Pink Shrimp

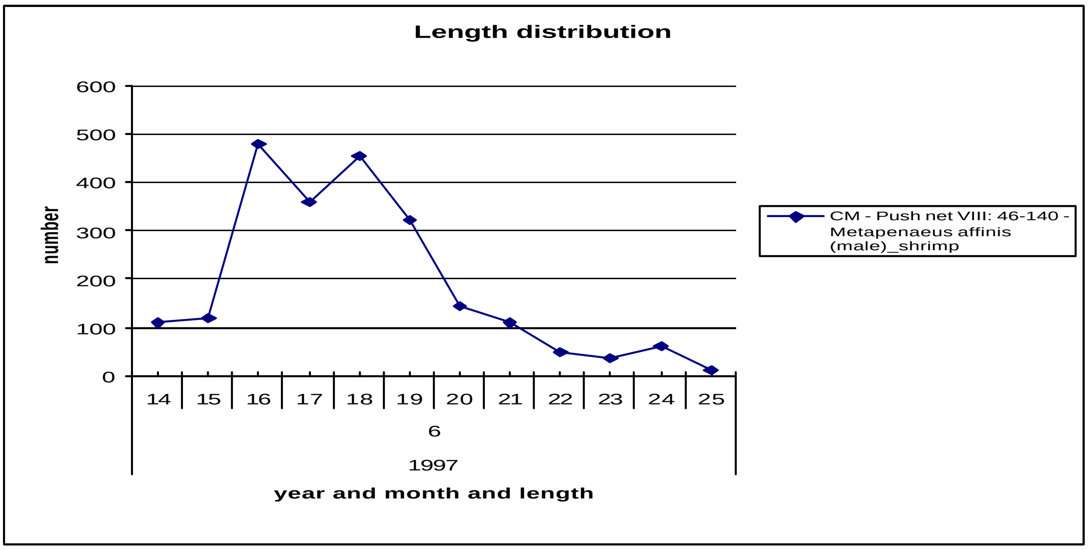



Figure 3.4.88

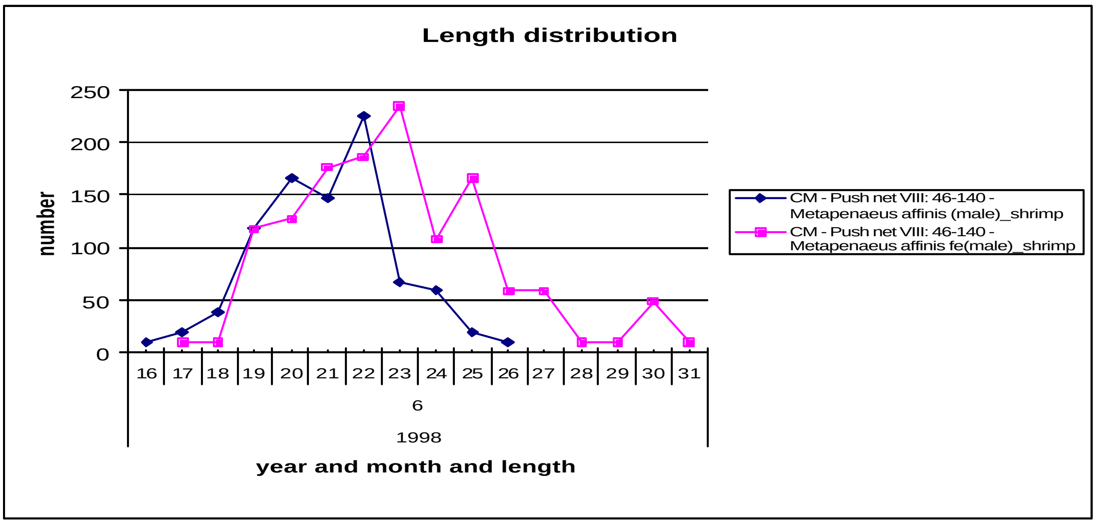



Figure 3.4.89

*Figure 3.4.88-3.4.89:* The average sizes of *Metapenaeus affinis* in the push net catches from June 1997 and July 1998 are significantly smaller than in the trawl catches from June and July 1997.

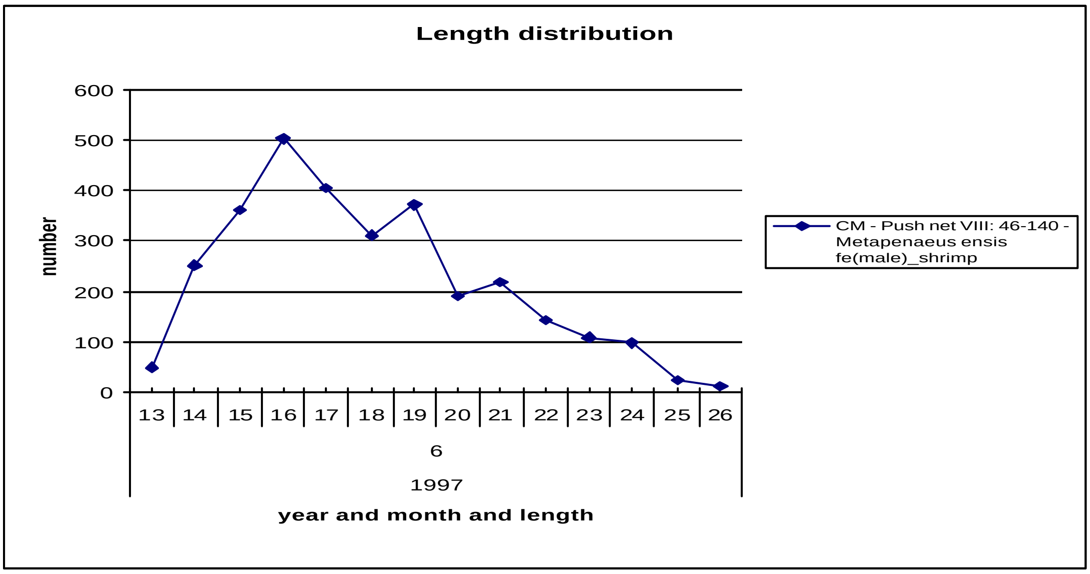



Figure 3.4.90

*Figure 3.4.90:* The average size of *Metapenaeus ensis* from push net catches June 1997 is significantly smaller than in the trawl catches June 1998.

White shrimp:

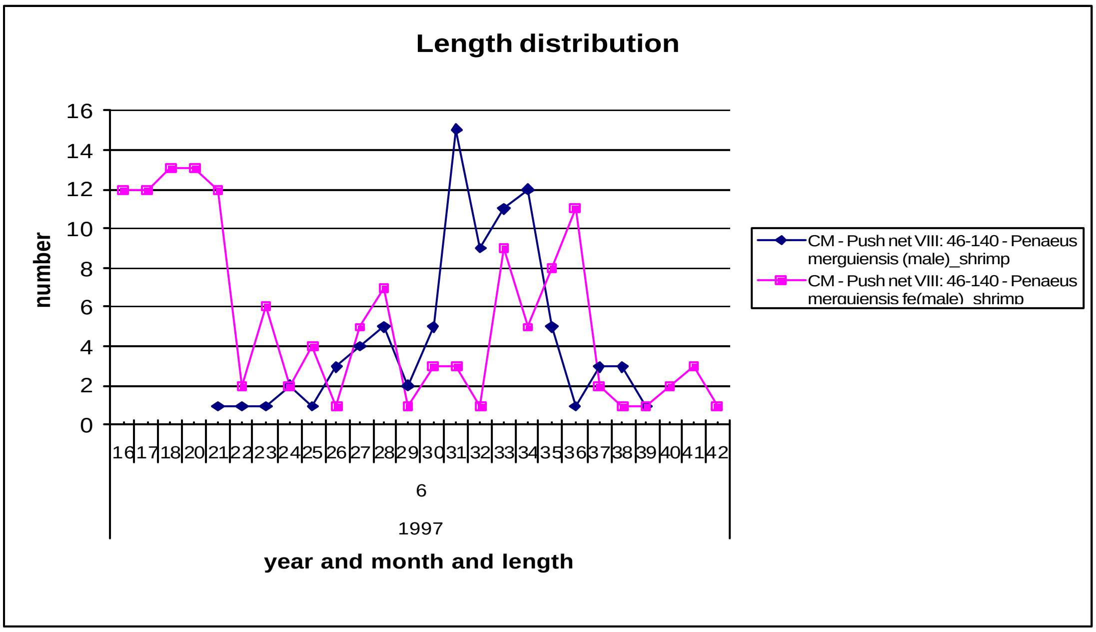



Figure 3.4.91

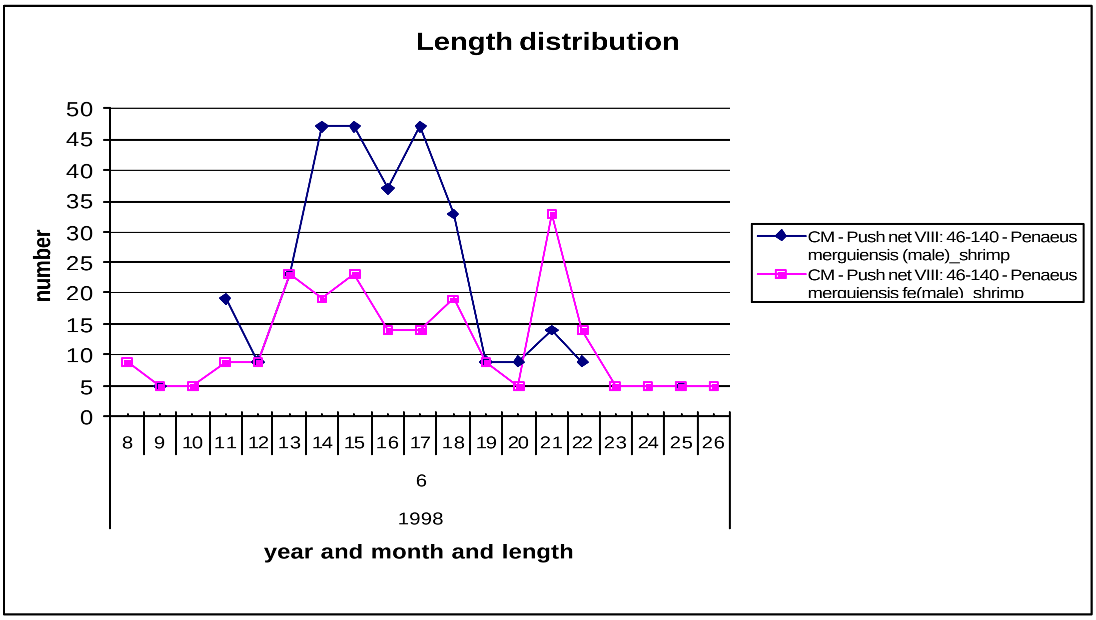



Figure 3.4.92

*Figure 3.4.91-3.4.92* indicate that size distribution for the *Penaeus merguensis* taken in the push net fishery is more wide than the size distribution in the trawl fishery. The push net catches seem to include the same size groups (larger than 20mm) as the trawl catches (Figure 3.4.83-3.4.84) but in addition include much smaller shrimp down to 8mm.

### *3.4.6 Synthesis*

The text tables below indicate the statements within the three groups relating to distribution and migration, habitat factors and preference, and abundance. For each statement is indicated the percentage agreement expressed by the offshore and inshore fishermen and a verifier indicating weather the statement is supported by the available data or not. As the enumerator data and the official catch statistics do not include detailed information about catch location or water depth at the fishing grounds distribution and migration statements and the habitat related statements could be addressed by the literature review only. For a more thorough analysis of these statements is referred to Moser and Macintosh (REF).

**Text table 3.4.4: Distribution and migration statements**

Statement verifiers: Yes: agreement; No: disagreement; n/a: information not available. Italic statement verifier indicates agreement with stakeholder group

| | Statements | Stakeholder and data agreement Offshore % | Inshore % | Data |
|---|---|---|---|---|
| 1 | Offshore shrimp species is to stay offshore their whole lives and inshore shrimp species live in inshore their whole lives | 48 | 56 | No |
| 4 | Only prawn in fresh water has visible eggs. | 36 | 56 | n/a |
| 7 | Shrimp will move to shallow places when they become adult | 48 | 53 | No |
| 10 | Sat[1] shrimp stay offshore, from December to January | 55 | 81 | n/a |
| 13 | Off: Shrimp breed in the off shore<br>In: Shrimp breed in the shallow places | 48 | <br>60 | Yes<br>*No* |
| 16 | Off: In south wind season shrimp come to stay in deep places<br>In: Bac[2] has eggs from May to August | 77 | <br>72 | n/a<br>n/a |
| 19 | Off: Large, adult shrimp stay in the offshore areas.<br>In: When wind from the sea brings up water, shrimp in the ponds will move to the river | 87 | <br>91 | *Yes*<br>n/a |
| 22 | Off: Su[3] shrimp brood stock live in shallow water.<br>In: Dat[4] shrimp is much more in shallow water | 7 | <br>100 | No<br>*Yes* |
| 25 | Off: Chi bong[5] shrimp stay in inshore, shallow places.<br>In: Chi[6] shrimp is caught in shallow water | 68 | <br>28 | *Yes*<br>Yes |
| 28 | Off: Gay[7] shrimp often concentrate in depth water levels whole year<br>In: Giang[8] shrimp is caught in deep places | 94 | <br>31 | n/a<br>*No* |

[1]*Parapenaeopsis sculptilis*
[2]*Metapenaeus tenuipes, M. brevicornis, M. lysianassa*
[3]*Panaeus monodon*
[4]*Metapenaeus ensis*
[5]*Metapenaeus affinis*
[6] *Parapenaeopsis cornuta, P. hardwickii*
[7]*Metapenaeus hungerfordi, Trachypenaus curvirostris*
[8]*Parapenaeopsis gracillima*

Regarding:

Statements 1, 7, 13: There is a high level of disagreement within each stakeholder group about the shrimp lifecycle. According to the literature, shrimp nursery areas are mostly found in estuarine environments. As the shrimp grow larger specimens tend to migrate offshore. Breeding takes place offshore and the offshore larval development takes about three weeks.

Statements 19 offshore, 22 offshore: There is a high agreement within the offshore stakeholder group that large adult shrimp stay in the offshore areas (19 offshore). This is consistent with the high agreement that the Su (*Paneus monodon)* brood stock shrimp does not live in shallow waters (22 offshore). In both cases the perception of the offshore stakeholder is supported by the literature.

Statement 22 inshore: The inshore stakeholder group agree entirely that the Dat shrimp (*Metapenaeus ensis*) is most abundant in shallow waters. According to literature the Dat shrimp are adapted to sub-tide areas in estuaries or near estuaries. This is supportive of the inshore stakeholder perception.

Statement 25 offshore: The majority of the offshore stakeholder group agree that the Chi bong shrimp (*Metapenaeus affinis*) stay in inshore shallow places. According to literature the Chi bong shrimp are adapted to sub-tide areas in estuaries or near estuaries. This is supportive of the inshore stakeholder perception.

Statement 25 inshore: The majority of the inshore stakeholder group are in disagreement with the statement that Chi shrimp (*Parapenaeopsis cornuta, P. hardwickii*) is caught in shallow waters. Supportive of the statement and in disagreement with the inshore fishermen, the literature on shrimp life history indicates that the Chi shrimp are adapted to sub-tide areas in estuaries or near estuaries.

Statement 28 inshore: The majority of the inshore fishermen are in disagreement with the statement that Giang shrimp (*Parapenaeopsis gracillima*) is caught in deep places. According to the literature the adult Giang shrimp are adapted estuaries with high and stable salinities. Assuming that estuaries are not considered deep places the statement is in disagreement with the literature.

**Text table 3.4.5: Habitat factors and preference statement**

Statement verifiers: Yes: agreement; No: disagreement; n/a: information not available. (Italic statement verifier indicates agreement with stakeholder group)

| Statements | | Stakeholder and data agreement | | |
|---|---|---|---|---|
| | | Offshore % | Inshore % | Data |
| 3 | Off: Rainfall is not effective to shrimp yield when catch offshore<br>In: If shrimp lives in root of the mangrove, they will grow faster. | 87 | <br>72 | n/a<br>*Yes* |
| 6 | Off: All shrimp like to stay in transparent water<br>In:. If the current is stronger the bottom becomes muddier, but a weak current will make the bottom sandier. | 19 | <br>22 | No<br>n/a |
| 9 | Off: The water temperature is gradually increasing from the coastline to offshore in the dried season<br>In: The water balloon can be seen from June to August | 35 | <br>69 | n/a<br>n/a |
| 12 | Off: Normally, water temperature is low from November till January then it starts to increased to May<br>In: Fishing ground has been changed in rainy season from place to place due to high water turbidity | 87 | <br>94 | n/a<br>n/a |
| 15 | A North wind means we will catch fewer shrimp | 77 | 97 | n/a |
| 18 | Turbid water has a higher yields than transparent water | 61 | 63 | n/a |
| 21 | Shrimp live in the mud bottom have low value but high yield | 81 | 78 | Yes/No |
| 24 | Each different species will have different areas of spawning ground. | 100 | 93 | n/a |
| 27 | The salinity of sea water is highest in August and lowest in March. | 13 | 13 | n/a |
| 30 | In the nature, species have ability to tolerate large exchange salinity. | 97 | 100 | Yes/No |

Regarding

Statement 3 inshore: The majority of the inshore fishermen agree that if shrimp live in the roots of the mangrove they will grow faster. According to literature most shrimp are dependent on mangrove nursery areas. This is supportive of the inshore fishermen perception.

Statement 6 offshore: The offshore fishermen do not agree that all shrimp like to stay in transparent water. Also the literature is not supportive of this statement as e.g. species of the euryhaline sub group of the estuarine group are adapted to low water transparency.

Statement 21: Both offshore and inshore fishermen agree that shrimp living in mud bottom have low value and high yield. However, this statement is only partly supported by the literature. The adult specimens of the island and offshore group are adapted to areas with mud or mud-sand sediments. This group comprise high value species as *Penaeus monodon* and *P. japonicus* as well as low value species as *Parapenaeus longipes* and *P. fissarus.*

Statement 30: Both offshore and inshore stakeholder groups agree that shrimp species have ability to tolerate large fluctuations in salinity. However, this statement is only partly supported by the literature. Some species belonging to the estuarine group (like *Penaeus merguensis, P. indicus, Parapenaeopsis hardwikii and Metapenaeus* affinis of the oligohaline sub-group) are adapted to stable salinity, whereas other species (like *Metapenaeus ensis* and *M. monoceros* of the euryhaline sub group) are adapted to large fluctuations of salinity.

**Text table 3.4.6: Abundance statements**

Statement verifiers: Yes: agreement; No: disagreement; n/a: information not available. (Italic statement verifier indicates agreement with stakeholder group)

| Statements | | Stakeholder and data agreement | | | |
|---|---|---|---|---|---|
| | | Offshore % | Inshore % | Data | |
| | | | | BL | CM |
| 2 | Shrimp catch composition has not changed | 58 | 69 | No | No |
| 5 | The yield of shrimp has decreased every year | 87 | 94 | No | No |
| 8 | The yield of shrimp reduced suddenly last year (2001) | 61 | 53 | *(Yes)* | *(Yes)* |
| 11 | The yield of some species has increased while the yield of others has reduced. | 55 | 47 | No | No |
| 14 | Since 1986, the shrimp yield has reduced rapidly | 77 | 81 | (Yes) | (Yes) |
| 17 | Off: Gay[1] shrimp became few but now there are many more<br>In: The gay[1] shrimp had a high yield in the past , but it is much less at present | 55 | <br>94 | Yes<br>*Yes* | No<br>*Yes* |
| 20 | Off: The Gay[1] shrimp became very few about 4-5 years ago.<br>In: The The[2] shrimp became very few about 4-5 years ago. | 65 | <br>94 | *Yes*<br>*Yes* | *Yes*<br>*Yes* |
| 23 | Off: Very few sat[3] shrimp are caught.<br>In: Very few giang[4] shrimp are caught | 81 | <br>68 | *Yes*<br>n/a | *Yes*<br>n/a |
| 26 | Off: In the three recent years, the yield of Giang[4] shrimp has reduced more than the others<br>In: In the three recent years, the yield of Gay[1]shrimp has reduced more than the others | 87 | <br>97 | n/a<br>(No) | n/a<br>(No) |
| 29 | Off: I hardly catch Su[5] shrimp<br>In: The natural shrimp decrease year by year | 36 | <br>94 | Yes<br>*Yes* | Yes<br>*Yes* |

[1]*Metapenaeus hungerfordi, Trachypenaus curvirostris*
[2]*Panaus merguienesis, P. japonicus, P. indicus*
[3]*Parapenaeopsis sculptilis*
[4]*Parapenaeopsis gracillima*
[5]*Panaeus monodon*

Regarding
Statement 2: it is the perception of the majority of both offshore and inshore fishermen that the catch composition has not changed. Although this may be true with regard to what species are caught the enumerator data indicates that there has been significant changes in catch ratios of various commercial groups. As an example, both the catch rates (Figure 3.4.21 and 3.4.51) and the contribution to total shrimp catch (Figure 3.4.22 and 3.4.52) of the high value white prawns have decreased in both BL and CM during the last five or six years. In BL also the catch rates (Figure 3.4.16) and the contribution to total catch (Figure 3.4.17) of pink prawn has decreased since 1997. Apparently, a number of good pink prawn year classes assured high catch rates in CM a couple of years longer than in BL (Figure 3.4.46). However, also in CM the pink prawn catch rates decreased after 1999 to a level similar to the one before 1997. Since 1999 the contribution of pink prawn to the total shrimp catches has decreased from about 40% to about 10%.

Statement 5: There is a high agreement among both the offshore and the inshore fishermen that the yield of shrimp has decreased every year. This perception is not supported by the enumerator data. Both in BL (Figure 3.4.2) and CM (Figure 3.4.32) the catches have fluctuated around a more or less stable level since beginning of 2001 in the absence of strong recruiting year classes. However the enumerator data does support the perception that there was a downward shift in the average catch rate level in BL around 2001. Before 2001 the shrimp fishery was characterised by large fluctuations in catch rates most likely driven recruitment of strong year classes. At that time the average catch rate was about 8kg/hour with annual peaks as high as 12 and 14kg/hour. After 2001 the catch rate peaks have disappeared and the average catch rate about 20% less than before.

Statement 8: A little more that half of both the offshore and inshore fishermen agreed (somehow conflicting with the agreement in statement 5) that the yield of shrimp suddenly decreased in 2001. For both BL and CM the enumerator data indicate that the catch rates were below average in beginning of 2001. In particular for BL there are indications that the lack of strong year classes in 2001 and 2002 resulted in catch rates that are maintained at the low level. Apparently, the catch rates in Ca Mau were in 2002 back at the same level as observed before the decrease in beginning of 2001. However, according to additional information from the enumerators many vessels left the shrimp fishery during 2001 due to unprofitability. Therefore, the increase in catch rate might not necessarily be a result of an improving shrimp stock.

Statement 11: There is virtually no agreement in any of the stakeholder groups to weather it is true or not that the yield of some species has increased while the yield of others has reduced. The enumerator data indicates that the catch rates of some species have had a declining trend but there are no indications of increased long term trends in catch rates for any species.

Statement 14: There is a good agreement within both stakeholder groups that the shrimp yield has declined rapidly since 1986. The enumerator data time series goes back to 1996 only but the survey data indicate a much higher shrimp catch rates and density in the period 1975-85 than at present. However, if a 50% decrease in catch rates taking place over 15 years can be characterised as a rapid decrease for short lived species as tropical shrimps is a matter of definition.

Statement 17 offshore: There is a high disagreement in the offshore stakeholder group to weather the Gay shrimp (*Metapenaeus hungerfordi, Trachypenaeus curvirostris*) has recovered after having been depleted or not. Supportive of the statement, the enumerator data from BL (Figure 3.4.12 and 3.4.14) indicate that the dog shrimp in 2002 reappeared in the catches after having been absent since 1998. Also, the Southern rough shrimp reappeared in the catches after having been absent since mid 1999 (apart from a few catches around the turn of the year 2000/2001). In Ca Mau the dog shrimp disappeared in beginning of 2000 not to reappear (Figure 3.4.42) and the catch rates of the Southern Rough Shrimp has decreased from around 6kg/hour in 1998 to almost nothing in 2002 (Figure 3.4.44). These observations are not supportive of the statement.

Statement 17 inshore: The inshore fishermen agree almost entirely that the Gay shrimp (*Metapenaeus hungerfordi, Trachypenaeus curvirostris*) has declined. Following the argumentation for statement 17 offshore, the enumerator data support this perception.

Statement 20 offshore: A little more than half of the offshore fishermen agree that the Gay shrimp (*Metapenaeus hungerfordi, Trachypenaeus curvirostris*) became few about 4-5 years ago. The enumerator data goes back to 1996 only and does not give any indication of the catch rates prior this year. Therefore, apart from the points made under statement 17, this data provides no information supporting or rejecting that a sudden reduction in catches of these shrimp species took place 4-5 years ago.

Statement 20 inshore: The inshore fishermen agree almost entirely that the The shrimp (*Panaus merguienesis, P. japonicus, P. indicus*) became very few about 4-5 years ago (1997-1998). The enumerator data goes back to 1996 only and does not give any indication of the catch rates prior this year. Therefore, this data provides no information supporting or rejecting that a sudden reduction in catches of The shrimp took place 4-5 years ago. However, the enumerator data from both BL and CM does indicate that the Banana prawn commercial group has not occurred since the end of 1999 (Figures 3.4.25 and 3.4.55) and that landings of Kuruma prawn only occurred in the landings during a few month by the turn of the year 2000 to 2001 (Figure 3.4.26 and 3.4.56).

Statement 23 offshore: There is a high level of agreement among the offshore fishermen that very few sat shrimp (*Parapenaeopsis sculptilis*) are caught. The enumerator data indicate that in BL the catch rate of sat shrimp have fluctuated between 0 and 1kg/hour since 1997. In CM the sat shrimp has not appeared as a separate commercial group since middle of 2000 and before that the catch rates were fluctuating between 0 and 0.1kg/hour. In bout areas the catch statistics is supportive of the statement and in agreement with the stakeholders.

Statement 26 inshore: The inshore fishermen agree almost entirely that the yield of Gay shrimp (*Metapenaeus hungerfordi, Trachypenaeus curvirostris*) has decreased more than the others during the recent 3 years (1999-2001). As discussed under statement 17 in BL the dog shrimp was absent in the catches from 1998 to 2001 (Figure 3.4.12) and the Southern Rough shrimp almost absent from 1999 to end of 2001 (Figure 3.4.14). However they both reappeared in 2002. In Ca Mau the dog shrimp has been absent since middle of 2000 and the Southern Rough shrimp that had catch rates at 5kg/hour in beginning of 2001 is now very rare as a separate commercial group. However, taking into consideration that other commercial groups have disappeared also it would not be fare to state that the yield have reduced more than (all) others.

Statement 29: The offshore fishermen do not agree that they hardly catch Su shrimp (*Panaeus monodon*). The enumerator data indicate that in both Bac Leu and Ca Mau the catch rates of Tiger shrimp were high in 1998 (0.03kg/hour) but has been fluctuating between 0 and 0.01 since 1999 (Figure 3.4.24). As these catch rates can not be said to be high the enumerator data is not supportive of the perception of the fishermen.

Statement 29 inshore: The inshore fishermen agree that the natural shrimp (abundance?) decrease year by year. This perception is supported by the scientific surveys indicating a decline in density from 168kg/km$^2$ in the period 1975-85 to less than 100kg/km$^2$ in 2001.

### *3.4.7 Discussion*

The enumerator database comprises detailed information about the performance of the fishing fleets in Vietnam and could prove a valuable tool in establishing time series of fisheries indicators supporting fisheries management.

The enumerator data indicate that despite a reduction in catch rates, the shrimp is still the most important resource for the trawl fleets in South Vietnam.

There seem to be two major differences with regard to the shrimp catch rates in the two areas evaluated. The data from Bac Leu (Figure 3.4.3) indicate that in the South China Sea the shrimp contribution to the total catches declined from about 50% in 1997 to about 30% from 1998 onwards. Only the smallest vessels (OT<20HP) with very low total catch rates (less that 5kg/hour) have maintained a high shrimp proportion (between 60 and 80%). The data from Ca Mau (Figure 3.4.33) indicate that in the Gulf of Thailand the shrimp contribution to the total catches was about 40% until end of 2001. During 2002 a 10-15% decline was observed for both fleets with data.

Not only did the decline in average shrimp contribution to total catch occur four years later in Ca Mau than in Bac Lieu but in Ca Mau often the larger trawlers (OT>140HP) have a very low proportion of shrimp indicating shifting target species or that, occasionally, large amount of low value fish were taken as by-catches. This is supported by additional information (not included in the database) from the enumerators in Ca Mau indicating that several of the larger vessels formerly targeting shrimp have changed gear and target species in 2002.

Although the contributions of shrimp value to the total catch values reflect the declining catch rates of shrimp this group still includes the most important species from an economic perspective in both Bac Leu and Ca Mau. For all trawlers but the smallest in Bac Leu, the shrimp contribution to total catch value declined from a level fluctuating between 75 and 90% in 1997 to the present level fluctuating between 60 and 75% (Figure 3.4.4). The shrimp contribution to total catch value of the OT<20HP fleet has remained above 80% throughout the whole period. In Ca Mau the shrimp value contribution to the total catch value fluctuated around 80% for all fleets until middle of 2000 (Figure 3.4.34). After 2000 the shrimp value contribution for the large trawlers often dropped down to 60% whereas it increased to more than 80% for the other fleets. From middle of 2001 the shrimp value contribution have declined to the present level around 60%

From beginning of 1998 until beginning of 2002 cat prawn was the most important shrimp catch group in Bac Leu. In this period the cat prawn contributed between 80 and 90% of the total shrimp catches interrupted only by shorter (few months) periods with very low catch rates. Apparently, before 1998 and again in 2002 the cat prawn contributed about 20-40% to total shrimp catches only. In Ca Mau the picture is quite different. Here the contribution of cat prawn has been very low except from may 1999 to August 2000 when they contributed between 60 and 100% of the total shrimp catches.

In both Bac Leu and Ca Mau the cat prawn contribution seem to have fluctuated in counter phase with the Low Value Shrimp contributions. Consequently in Bac Leu the LVS are abundant in the catches only in the few month with low cat prawn contribution and in Ca Mau LVS are abundant in all months but the few when the cat prawn were abundant. It is *suggested* that the relationship between the cat prawn commercial group and the LVS group should be investigated in more detail by interviews of enumerators and fishermen and if necessary by additional data collection.

In Bac Leu catch rates of pink prawn, white prawn and yellow shrimp have all declined since 1997. In Ca Mau pink prawn catch rates have remained almost constant whereas white prawn catch rates have declined and yellow shrimp disappeared entirely as a separate commercial group in 2001.

It is difficult to use the enumerator data to discuss changes in the species composition as each of the catch groups include a commercial group of mixed species (pink prawn, white prawn, cat prawn) with unknown species composition. The single species commercial groups are only used when there is a sufficient catch of a certain species. Species with low catches are grouped together in the mixed species commercial groups. Without information from additional surveys about the species composition within these mixed groups it is difficult to discuss consistently to what extend lacking commercial groups reflects declining resources or a just a change of commercial group for this species due to low catch rates or maybe due to changing marked conditions. It is *suggested* that data are collected on a routine basis to identify the proportion of key shrimp species (e.g. those having separate commercial groups) in the mixed species commercial groups.

It is suggested that the seasonality in shrimp catch rates as indicated by the enumerator data should be investigated by more detailed statistical analysis. Seasonality in catch rates could reflect seasonality in shrimp recruitment to the fishery well know from other Panaeid fisheries, e.g. at the Sofala Bank, Mozambique. As in Mozambique, a fishery management system could take advantage of a seasonal pattern in the catch rates by closing seasons with low average size shrimp indicating high proportion of juvenile shrimp in the catches. It is *suggested* that the enumerator data collection programme is modified as to always indicate the number of shrimp in a sample of a known weight. This would be an easy and low cost way to obtain valuable information on average size of the shrimp that could be supportive of a fishery management system based on closed seasons.

In the present project, the synthesis of the abundance statements with the catch indicators were complicated by the fact that some of the Vietnamese terms relate to shrimp species not belonging to their own commercial group or they group together various commercial groups. It is believed that if the statements were related more to the commercial group concept it would have been easier to combine the perceptions of the fishermen with the available catch statistics.

Some of the abundance statements are so general in their formulation that they open up for individual interpretations that makes it is very difficult to verify if the perceptions of the fishermen are consistent with the scientific data. For example it is very difficult to evaluate if a commercial group has decreased more than the others if some commercial groups have disappeared entirely as separate groups.

In the present study, catch rates are used as an indication of abundance and there is no information about the total effort. As only the trawlers with shrimp in the catches are included in the present study this approach might lead to an over optimistic perception of the resource abundance if a significant part of the fleet, as in Ca Mau, change gear and shift target species.

In the present study, the inshore fishermen statements might not be reflected well by enumerator data, as it includes only trawl data and no information is given as to catch location. However, compared to the near shore fixed gears even the small trawlers might have a different catch composition and, therefore, another perception.

# 4. Discussion and Conclusion

## *4.1 Discussion and Conclusions from the Sociological Analysis*

### *4.1.1. Fit of the Cultural Consensus Model*

A shared local ecological knowledge was found to exist on both the lower Sedone River (Table 2.3.1) and Dam Doi shrimp fishery (Table 3.3.1) in the sense that the cultural consensus model fits the fishers' responses to the statements. This makes it possible to calculate "correct" answers in reference to the local knowledge and, therefore, to calculate the number of correct answers for the individual fishers. The amount of knowledge held by individual fishers was found to vary systematically among the fishers by the type of gear (Tables 2.3.3 and 3.3.4) and, in Laos, by the number of different types of gear that they use (Table 2.3.4). Other potential correlates with individual knowledge, i.e., where they fished and how long they had been fishing, were not found to matter. In both case fishers who use smaller gears such as traps and trammel nets, showed higher levels of LEK than the other fishers. The implication of this for LEK and simple management indicators is, first of all, that knowledge must be gathered from a number of people, particularly those that use different gears.

### *4.1.2. Categories of Knowledge*

Our attempt to classify statements and find systematic differences in levels of knowledge about fish abundance, fish habitat, or fish behaviour failed. While differences were found in which of these categories had higher or lower proportions of answers correct, which categories had the higher proportion and which had the lower proportion differed between different tests (Tables 2.3.2 and 3.3.2). This failure has serious implications for the use of LEK-based indicators. These three categories reflect very basic common sense within the scientific world view in that they express of the simplest ecological concepts: the individual animal; the species population; and the community or landscape. They reflect some simple assumptions that seemed clear to us in the beginning of the research about the relationship between fisher behaviour and levels of LEK. Fishers' differ in their ability to catch fish, so experiences related to abundance should be quite different. Meanwhile they are observing the same fish species over extended periods of time so they should have relatively high agreement about fish behaviour. Yet in three out of four tests, averages scores for abundance were higher than for behaviour (Tables 2.3.2 and 3.3.2). This result could reflect that inadequacy of the three categories, clear as they are from an ecological perspective, or it could reflect such a wide variation in difficulty among individual statements that differences between categories were swamped.

The research came at this same issue of knowledge categories that make sense inductively through the pile sorts done in Laos (Figures 2.3.1 and 2.3.2). While the knowledge categories created by the fishers and the fisheries officers were in many ways similar (as would be predicted by previous findings (Atran 1998)) important management-related differences in how objects and facts are categorized were found. Fishers associate lost fish abundance primarily with changes in habitat, while the officers associate it primarily with fishing techniques. Fishers categories are also more concrete than those of the officers. The officers, for example, classify all the management rules together in a 'rules' category, while the fishers classify rules with objects or activities related to the rules' content.

The most telling result related to this question of categories, however, is that the category of indicator itself does not fit very well with LEK. This became apparent as early as the initial key informant interviews when fishers, particularly in Laos, often rejected or had a hard time understanding the idea of an indicator of future fish abundance. The Dam Doi Q sort results (Table 3.3.8) show a very slight and variable relative support for the general idea of indicators. Two specific indicators that were suggested, water balloons and loss of mangrove forests, were both rated relatively negatively by the respondents. One, the idea that the current yield can predict the future yield did get very slight and variable support. This support came entirely from the offshore fishers (Table 3.3.9).

Whether the failure to find a general pattern using our pre-defined categories of behaviour, habitat or abundance is based on substance or methodology, the implication is that we do not know how to categorize LEK in a way that is useful for quickly developing management-related indicators. This limits the presuppositions we have available to us about what kinds of information are going to be useful in finding useful indicators acceptable to the fishers. On one level this is unavoidable because fisheries management by its nature requires imposing alien categories on local knowledge. It is important, however, to bear this problem of different ways of categorizing knowledge in mind when reading the discussion below where we try to reach conclusions about LEK and simple indicators of management.

### *4.1.3 Distribution of LEK*

One result of this research (one that has also been found by similar research in Africa), is that the fishers with the highest level of LEK are the fishers who fish using smaller gears that are, in fact, frowned upon by the government fisheries managers. The result is clearer in Dam Doi, where the comparison is between smaller stationary gears, large stationary gears, and large trawl-like gears (Table 3.3.4) than it is in Laos, where the trap fishers have slightly more LEK than the other artisanal fishers (Table 2.3.3), but where using more types of gear has an even greater influence (Table 2.3.4). The reason for the result is very likely both the greater need that these have for LEK to make their smaller-scale operations successful and the closer interaction with the environment that the gears require. This result suggests that fisheries development may be reducing the value of LEK as a source of useful raw knowledge, although this would not have any impact on the need to understand LEK in relation to scientific legitimacy. Many approaches to gathering LEK rely on the use of key-informants who are identified by various techniques such as asking local fishers who they think are the most knowledgeable. With the development of fisheries, these informants may be becoming less representative of the general fishing community, even in situations where the idea of a "general fishing community" is a reasonable fit with the level of diversity in the fishery.

Inshore fishers in Dam Doi having either greater or equal LEK about all the indicator-related statements (Table 3.3.6) reflects this difference in gears (Table 3.3.7) and reminds us that such differences have regional implications as well. The findings for salinity and fecundity uncovered an interaction between region and the scale of operations, for this possible indicators it is the larger gear that shows the higher levels of related LEK, though only observations about salinity seem possibly reliable. It is political and economic issues that drive the regional (inshore v offshore) disagreement about management policies related to the role of the mangrove forest, and hence its value as an indicator of a healthy shrimp stock (Table 3.3.9, Figures 3.3.1 and 3.3.2). Inshore people, who live in it, see the mangrove forest as a source of income while offshore people want the mangrove protected because they see it as important in maintaining a healthy stock.

### *4.1.4 Indicators and LEK*

The reliability of LEK for various kinds of statements is quite different between cases and somewhat different between the two regions in the Dam Doi case. LEK is a highly contextual phenomenon that varies strongly between different places and gears and that is difficult to capture. The primary conclusion of this analysis must be the following: using simple indicators for management does not substitute for ongoing interactions between scientists and fishers where management goals are set, and refined. Such interactions must include the identification and reidentification of indicators that tell the stakeholders when those goals are reached. Indicators are part of a larger process and cannot be understood when abstracted from that process.

Given these considerations, this research allows us to at least rank the candidate indicators according to the proportion of correct answers. This is an index of both how well these potential indicators reflect the fishers' LEK and how useful that LEK would be in identifying indicators of these types. This one of the tasks where we are forced to place the statements in categories which do not necessarily reflect local understandings. In Laos (Table 2.3.5) catch composition (fish size and species diversity) has the best fit. In fact, this is likely the only kind where the proportions of correct answers are high enough to be usefully reliable. The next best are catch rates and spawning behaviour. Third tier statements are those related to the level of water and the single statement about the number of people fishing. Finally, statements about water quality (which include three statements about the characteristics of the river water and one about bottom composition) generated nearly random responses from fishers. A reasonable conclusion is that the river's appearance changes too much and too often to expect fishers' observations about it to agree.

For the Dam Doi inshore fishers (Tables 3.3.6 and 3.3.7) the most reliable observations were those related to salinity, the geographical distribution of the shrimp, wind and spawning behaviour. These last two are both single and fairly easy statements. Catch rates are the second tier and with an average proportion correct of .83 this information is, perhaps, borderline reliability depending on what they information needs to be used for. Information about size distribution, catch composition, changes in mangrove cover and fecundity all cluster around 70% correct.

The Dam Doi offshore fishers are fairly similar to the inshore fishers in where the statements cluster, but their highest proportion correct is .81 for turbidity. The top tier is the same except that wind drops out and turbidity are added. Interestingly, reports about salinity do show a quite reliable level when only fishers using larger gears are involved. None of the rest of the indicators seem to fit well with the LEK of the offshore fishers.

In general, as would be expected, higher scores are found for those natural conditions which appear similar across wide areas. In Laos these conditions attach more to the stocks with such things as fish size and diversity, catch changes, spawning behaviour rather than to the environment because environmental conditions along the river are so varied. This is an important contrast with the fact that the Laotian fishers consider environmental conditions important as an indicator of fish abundance (Figure 2.3.1). In Viet Nam the more general conditions are environmental, e.g. salinity, temperature, and not as much to the condition of the stocks changes, although catch rates are borderline reliable in the inshore.

#### *4.1.5 Indicators and Management Discourses*

In Laos there does not seem to be as sharp a split as is found in Viet Nam, at least among the stakeholders directly related to fishing, as opposed to other groups wishing to make use of the rivers for water or power. There are clearly some scale-driven differences, as was partially reflected in the differences between the two pile sorts (Figures 2.3.1 and 2.3.2). The deep pools and the fish conservation zones are the issues that get the most debate and the questions that have been raised deal directly with scale: Of what use are small fish conservation zones in trying to manage the huge Mekong system (Hirsch 1998)? The response is that these deep pools are critical for maintaining stocks of important food fish during the low water season, an observation attributed to LEK (Baird 2000). The deep pools / fish conservation zones are a place where fishers' concerns with the environment and officer's concerns with fishing pressure can be brought together in a cooperative management plans. The indicators that need to be developed are indicators about the effectiveness of these zones. This may be challenging in light of the difficulties with agreement around water depth and qualities, though it is clear that fish behaviour, particularly spawning behaviour which relates to deep pools for some species, is strongly reflected in Laotian LEK (Tables 2.3.2 and 2.3.5).

In Viet Nam the divisions in terms of both knowledge and management options seem more stark. Both habitat and fishing techniques are areas of disagreement. There is a fairly dominant discourse among the non-fisher respondents that supports new technology and places the blame for the fall in shrimp production on overfishing inshore by small boats (Figure 3.3.1). This same basic position reflects the beliefs of many fishers as well, but another group of fishers sees this problem as one of the mesh sizes being used (Figure 3.3.2).

Among the kinds of statements where Dam Doi LEK seems reliable, i.e. salinity, geographical distribution of species, wind, spawning grounds and turbidity it is spawning and geographical distribution that are the most relevant to management discussions. The idea of protecting spawning shrimp is seen as both feasible and biologically reasonable from the LEK perspective. Several statements about the geographical distribution were related to shrimp life cycles. Two Q sort statements about protecting juvenile shrimp and brood stocks have relatively high mean scores, the one about juvenile shrimp has the second highest mean of all 16 statements. In the Q sort factor analysis for fishers protecting juvenile shrimp is the central goal in two factors, four and five (Figure 3.3.2) one of which, factor five correlates positively with consensus analysis scores, meaning that it is supported by the fishers with the highest LEK. Fishers supporting Factor Five want to protect juvenile shrimp through mesh size control, however, while the more specialized and larger scale fishers who support Factor Four want to do so by reducing the small scale, inshore fishing. Among non-fishers the protection of juveniles is central to only one, factor, which is supported by shrimp dealers.

The protection of spawning areas is also related to the main disagreement among fishers, the roles that mangrove forests play in protecting juvenile shrimp. This is expressed in disagreement over the purpose of the main government policy programme, the Integrated Mangrove and Aquaculture Model. Offshore fishers and fishing communities are very concerned that this habitat be protected and see this as the main purpose of the programme. Inshore fishers and fishing communities, on the other hand, see it more as an aquaculture development programme. It is unlikely that there would be any agreement about using the extent of the mangrove forests as an indicator of fisheries health.

## *4.2 Discussion and Conclusion for the Biological Analysis*

### *4.2.1 Vietnam*

The enumerator database in Vietnam comprises detailed information about the performance of the fishing fleets and could prove a valuable tool in establishing time series of fisheries indicators supporting fisheries management.

Preliminary analysis at the ecological group level indicated that despite a declining trend shrimp is still the most important ecological group for the shrimp trawlers in both areas under investigation. However, there were indications that large trawlers in Ca Mau might be shifting gear and target species.

Preliminary analysis at the catch group level indicated that in Bac Leu Cat Prawn is the most important catch group and that in both Bac Leu and Ca Mau the catch rates of Cat Prawn fluctuate in counter phase with the Low Value Shrimp catch group. In Bac Leu catch rates of pink prawn, white prawn and yellow shrimp have all declined since 1997. In Ca Mau pink prawn catch rates have remained almost constant whereas white prawn catch rates have declined and yellow shrimp disappeared entirely as a separate commercial group in 2001.

It proved difficult to analyse the enumerator data at species level as each catch group include a commercial group of mixed species (pink prawn, white prawn, cat prawn) with unknown species composition. Without information from additional surveys about the species composition within these mixed groups it is difficult to discuss consistently to what extend lacking commercial groups reflects declining resources or just a change of commercial group for this species due to low catch rates or maybe due to changing marked conditions. It is *suggested* that data are collected on a routine basis to identify the proportion of key shrimp species (e.g. those having separate commercial groups) in the mixed species commercial groups.

The enumerator data indicated seasonality in shrimp catch rates that reflect seasonality in shrimp recruitment to the fishery that are well know from other Panaeid fisheries, e.g. at the Sofala Bank, Mozambique. As in Mozambique, a fishery management system in Vietnam could take advantage of a seasonal pattern in the catch rates by closing seasons with low average size shrimp indicating high proportion of juvenile shrimp in the catches.

It is *suggested* that the apparent seasonal pattern in shrimp catch rates should be investigated by more detailed statistical analysis and that the enumerator data collection programme is modified as to always indicate the number of shrimp in a sample of a known weight. This would be an easy and low cost way to obtain valuable information on average size of the shrimp that could be supportive of a fishery management system based on closed seasons.

In the present project the enumerator data were applied to verify 15 statements relating to abundance and the results were compared to the output of the consensus analysis including inshore and offshore fishermen as indicated in the text table below.

**Text table: Abundance statements**

Statement verifiers: Yes: agreement; No: disagreement; n/a: information not available. (Italic statement verifier indicates agreement with stakeholder group)

| Statements | | Stakeholder and data agreement | | | |
|---|---|---|---|---|---|
| | | Offshore % | Inshore % | Data | |
| | | | | BL | CM |
| 2 | Shrimp catch composition has not changed | 58 | 69 | No | No |
| 5 | The yield of shrimp has decreased every year | 87 | 94 | No | No |
| 8 | The yield of shrimp reduced suddenly last year (2001) | 61 | 53 | *(Yes)* | *(Yes)* |
| 11 | The yield of some species has increased while the yield of others has reduced. | 55 | 47 | No | No |
| 14 | Since 1986, the shrimp yield has reduced rapidly | 77 | 81 | (Yes) | (Yes) |
| 17 | Off: Gay[1] shrimp became few but now there are many more<br>In: The gay[1] shrimp had a high yield in the past , but it is much less at present | 55 | <br>94 | Yes<br>*Yes* | No<br>*Yes* |
| 20 | Off: The Gay[1] shrimp became very few about 4-5 years ago.<br>In: The The[2] shrimp became very few about 4-5 years ago. | 65 | <br>94 | *Yes*<br>*Yes* | *Yes*<br>*Yes* |
| 23 | Off: Very few sat[3] shrimp are caught.<br>In: Very few giang[4] shrimp are caught | 81 | <br>68 | *Yes* n/a | *Yes*<br>n/a |
| 26 | Off: In the three recent years, the yield of Giang[4] shrimp has reduced more than the others<br>In: In the three recent years, the yield of Gay[1]shrimp has reduced more than the others | 87 | 97 | n/a<br>(No) | n/a<br>(No) |
| 29 | Off: I hardly catch Su[5] shrimp<br>In: The natural shrimp decrease year by year | 36 | <br>94 | Yes<br>*Yes* | Yes<br>*Yes* |

[1]*Metapenaeus hungerfordi, Trachypenaus curvirostris*
[2]*Panaus merguienesis, P. japonicus, P. indicus*
[3]*Parapenaeopsis sculptilis*
[4]*Parapenaeopsis gracillima*
[5]*Panaeus monodon*

Comparing the results from the consensus analysis with the enumerator data indicates that in five (statement 14, 17In, 20In, 23Off, 29In) of the eight statements with good agreement within the fishermen groups (agreement 75-100%) the enumerator data is supportive of the fishermen perception; no enumerator data was available for one statement (26Off) and two statements (5 and 26In) were difficult to interpret. The enumerator data indicate that is not true that the yield of shrimp decrease every year (statement 5) although the trend is significantly declining, and it is imprecise to suggest that the yield of Gay shrimp has reduced more than the others (statement 26In) when some species have disappeared completely.

In the present project, the synthesis of the abundance statements with the catch indicators were complicated by the fact that some of the Vietnamese terms relate to shrimp species not belonging to their own commercial group or they group together various commercial groups. It is believed that if the statements were related more to the commercial group concept it would have been easier to combine the perceptions of the fishermen with the available catch statistics.

In the present study, catch rates are used as an indication of abundance and there is no information about the total effort. As only the trawlers with shrimp in the catches are included in the present study this approach might lead to an over optimistic perception of the resource abundance if a significant part of the fleet, as e.g. the large trawlers in Ca Mau, change gear and shift target species.

In the present study, the inshore fishermen perceptions might not be reflected well by enumerator data, as it includes only trawl data and no information is given as to catch location. However, compared to the near shore fixed gears even the small trawlers might have a different catch composition and, therefore, another perception.

As the enumerator data indicate differences in catch rates between the two areas under investigation results from the consensus analysis could be affected if they are not analysed by area.

### *4.2.2 Laos*

In the Sedone River, most families living in the villages along the river were directly or indirectly involved in the fishing. Abundance of several fish species have gone down over the last years in the Mekong River, most likely due to a combination of population increase, the introduction of monofilament gill nets and increased fishing pressure. There are indications that most of the larger, predatory species are getting rare and that the dry-season migrants, that comes in from the Mekong have also decreased significantly. Increased use of irrigation may have influenced the water level of the river negatively, making fishing more difficult.

The main issue for the managers in Mekong seems to be the migrating fish that in that can be considered a shared resource outside influence of local management. If the Cambodian fishermen overexploits the migrating fish when they gather downstream the falls, the fishing in Laos will get worse and less fish will make it to the spawning area and less juveniles will come back down to Cambodian waters and so on. So if the decline in abundance of migratory fish is actually caused by increased fishing, there is an urgent need for hard regulations of the fishing in both the Lao and the Cambodian part of the waterfall area. So far our interviews have shown that most fishermen clearly have seen a gradually drop in catches of the migratory fish, but apparently not to the same degree in the stationary species. This is a strong indication that the main reason for poorer catches is actually the fishing in the waterfall area, or at least that fishing pressure affects the migrating fish more than the stationary. The percentage of fish caught in this area should be investigated and estimated to give recommendations for a management plan to insure the persistence of this unique resource.

The case study in the Sedone River, have shown that it is possible to gather information about the fishery and the condition of the river. This information may be used in the management system to issue regulations to protect the fish and secure a degree of sustainability in the fisheries. It is also clear that a fisheries management based on indicators of ecosystem condition evaluated by local knowledge is prone to make serious mistakes. Due to the lack of scientifically proven information of the fishes in the Mekong system, it is not possible to test the quality of the information provided by LEK, but ongoing attempts to provide time series of CPUE-data for several important species, may provide such information in the near future.

### *4.2.3 Common biological conclusion from the Two Case*

The experiences from the two case studies may lead to some general conclusions regarding the use of indicators in fisheries management in developing countries. In the case of the Vietnamese shrimp fishery, we investigated a restricted, commercial fishery including a limited number of species, where scientific/statistical data were available. In Laos, we focused on an artisanal fishery, where a large number of species were targeted using a variety of gear and methods and where no scientific data were available.

In both case studies we managed to get into meaningful conversation with the fishers and to obtain information about the fishery and the state of the resource. In both cases there was some degree of local consensus of the state of the aquatic resource and if correct, much of the information could be of value for the management.

In the Laos case study, we could only guess about the scientific value of the statements that were agreed upon, whereas we could evaluate some statements by catch statistics in Vietnam.

Despite language problems, the procedure applied in the present study proved useful to identify general LEK from the fishers but more complex issues as changes in abundance and catch rates over time were difficult to communicate. Thus, we can conclude that interviewing local fishers can be a method of obtaining basic information about the fishery and the resource, but this information is too weak to constitute the basis of management decisions alone.

It often suggested that fisheries sustainability indicators should be:

Observable

1. within economic resources for research on a sustained basis
2. by stakeholders, either directly or by transparency in the observation process

Understandable

3. they should have research based substance reflect analytical soundness
4. they should reflect features in accordance with stakeholders' understanding of the resource system

Acceptable

5. by fishers
6. by public at large

Related to management

7. they should have associated reference values

8. they should respond to management measures tIn both the Vietnamese and Mekong River case studies it proved possible to identify a set of resource indicators that are observable within existing resources. As the indicators were derived from the fishers LEK they should be understandable and acceptable at least to the fishers.

Due to lack of scientific data it was not possible to evaluate if the suggested indicators were scientifically sound in the Sedone/Mekong case.

In order to associate indicators to reference values, knowledge of the level and condition of fish populations at an undisturbed state is preferable but rarely obtainable in exploited systems.

However, some modelling of abundance may give satisfactory reference points, but much biological information is needed here.Whether the indicators respond to relevant management measures is also a point of uncertainty, due to the lack of biological information, lack of understanding of the catch effort relationship and lack of experience with restrictive management systems.

## *4.3 Final Conclusion*

There are several useful multidisciplinary results from the biological and sociological analyses. The basic conclusion of the biological analysis is that interviewing local fishers can be a method of obtaining basic information about the fishery and the resource, but this information is too weak to constitute the basis of management decisions alone. The basic conclusion of the sociological analysis is that a rough consensus about conditions in the fishery does exist among the fishers but that the degree of consensus is highly variable. In general, higher consensus is found in reference to those natural conditions which appear similar across wide areas. This is a very general observation, however. This research tried and failed to identify appropriate categories at an only slightly less abstract level. The basic reality is that we do not know how to categorize LEK in a way that is useful for quickly developing management-related indicators.

For the present cases some patterns did emerge. Agreement was found between fishers, on average, and the available scientific observations in Dam Doe about fish abundance. Agreement about abundance among fishers, however, was not high enough to be considered reliable. Abundance observations were less reliable than observations about environmental conditions, spawning behaviour and geographical distribution. The biological research, however, found systematic differences between the shrimp stocks on the western and eastern sides of Dam Doi, and, as data from these two areas were pooled during analysis, the consensus results in relation to abundance may have been biased towards a lower consensus. Spawning behaviour and distribution are both areas which are important for management in both Laos and Viet Nam and are recognized by the fishers as such. They are also related in both cases to political disagreement about potential management measures.

Problems with resources and the availability of systematic, scientific data indicate that this information will have to be supplemented by local knowledge for the sake of both having sufficient information and the legitimacy of management decision making. The main, practical conclusion of the present research is that using simple indicators for management does not substitute for ongoing interactions between scientists and fishers where management goals are set and refined. Such interactions must include the identification and reidentification of indicators that tell the stakeholders when those goals are reached. Indicators are part of a larger process and cannot be understood when abstracted from that process.

## References Cited

Atran, Scott 1998"Folk Biology and the Anthropology of Science: Cognitive Universals and Cultural Particulars" *Behavioural and Brain Sciences* 21:547-569

Boster, J.S. and J.C. Johnson 1989 "Form or Function: A Comparison of Expert and Novice Judgments of Similarity Among Fish" American Anthropologist 91:866-889

Baird, Ian G. 2000"Towards Sustainable Co-Management of Mekong River Inland Aquatic Resources, including Fisheries in Southern Lao PDR" International Institute for Environment and Development: Evaluating Eden Series Discussion Paper No. 15

Guest, Greg 2002 "Market Integration and Rapid Acquisition of Local Ecological Knowledge" *Journal of Ecological Anthropology* 6:38-49

Hirsch, Philip 1998 "Holding and Managing Resources in Common: Issues of Scale in Mekong Development" paper presented at Crossing Boundaries, the Seventh Biennial Conference of the International Association for the Study of Common Property, Vancouver, Canada 10-14 June

Romney, A. Kimball, Susan C. Weller and William H. Batchelder" 1986 Culture as Consensus: A Theory of Culture and Informant Accuracy" American Anthropolgist 88:313-338

# Appendix One: Guidelines for the In-depth Interviews

What follows are three sets of guidelines. One used in Laos and the other in Viet Nam

**Guidelines for LEK Interviews: Sedone River Case in Laos**

Hello, we are from the Living Aquatic Resources Research Centre. We are trying to learn more about the fish and the river environment in order to better protect and improve the fish resource. We have found that we can get a lot of information that will help us to have a better fishery in the future by talking to the fishermen. We would like you to please talk to us for about one hour about your fishing activities. We are not going to ask you anything about your fishing that you think is private and if you don't want to answer any question you don't have to. We are also not going to tell anyone else that you told us something. Because fishermen tell us so much useful information it is important that we be able to record what you tell us so that we can check back to make sure that we have understood it all. Can we please have your permission to use our tape recorder?

1. **Discussion of the maps and the layout of the area.** Lay the sketch map out on the table or the ground. Please show us the general areas where you fish during the year. How do you choose where you go to fish? Are there any places where you never go to fish? Why not? What fish do you fish for in each place? What gears do you use?

2. **Discussion of the time line.** Lay out the time line of the last 30 years. Ask: What have been the most important changes that have happened in the aquatic environment in the last 30 years? For each change ask: When did you first realize this was happening? How did you first now it was happening? Why did this change take place?

3. **Discussion of individual species.** What are for you the three most important fish? For each fish ask (if information was not provided in topic 1):

A) Why are these fish important to you? How do you fish for these fish? Are there other methods that other people use?

B) In the last few years has the average size of this species changed? When does this fish come to this area and when does it leave? Are there any times when the fish is never seen at all? Are there times when the fish is very abundant? From the catch of the species in one year can you tell how big the catch will be the next year?

C) Where does this fish spawn? Please describe how and where the fish grows during its life? What does it eat during these different times of its life? Where does it move to and from? Which are more important for having many fish, males, females or are they the same?

4. **Discussion of Management.** What are fishing rules that exist on this part of the Sedone? For each rule ask who made the rule and who enforces the rule. After they have listed all the rules ask which rules are most often violated and why. What other rules might be good to make? Who should make them?

5. **Discussion of long distance impacts.** Do you know much about what people are doing on other places along river? Which places? How do you learn about these things? How far away? Are there things that people in other places on the river that affect the environment and the fish here? How do you know that they are creating these changes? Are there things that you do that affect the fish fished by people in other places?

6. **Discussion of water level and quality.** What changes have you seen in the water itself? If not mentioned ask: What changes have you seen in the water level, colour, turbidity, or algae content. Do you thing these changes are important?

**Guidelines for LEK Interviews: Dam Doi Shrimp Fisheries in Viet Nam**

Hello, we are from Can Toh University. We are trying to learn more about the fish and the river environment in order to better protect and improve the fish resource. We have found that we can get a lot of information that will help us to have a better fishery in the future by talking to the fishermen. We would like you to please talk to us for about one hour about your fishing activities. We are not going to ask you anything about your fishing that you think is private and if you don't want to answer any question you don't have to. We are also not going to tell anyone else that you told us something. Because fishermen tell us so much useful information it is important that we be able to record what you tell us so that we can check back to make sure that we have understood it all. Can we please have your permission to use our tape recorder?

1. **Discussion of the maps and the layout of the area.** Lay the sketch map out on the table or the ground. *Please show us the general areas where you fish during the year. How do you choose where you go to fish? Are there any places where you never go to fish? Why not? What fish do you fish for in each place? What gears do you use?* How does your fishing change in different times of the year. Why? How does your fishing change with different tides? Why?

2. **Discussion of the time line.** Lay out the time line of the last 30 years mark end of war, mark beginning of reforms. *Ask: What have been the most important changes that have happened in the aquatic environment in the last 30 years?* For each change ask: *When did you first realize this was happening? Why did this change take place?*

*3.* **Discussion of individual species.** What have been the trends in catch rates. How have you responded in your fishing practices to these changes? Probe: Why this change. Any plans for the future. What have been the trends in catch composition? What are the different kinds of shrimp species. How do you separate them. What are for you the three most important economically?

For the three most important kinds of shrimp ask: Where do you catch the most of these shrimp? Where are they never seen? Where do they migrate and when? Where do you catch the juveniles? Where do you catch adults? Where do you find shrimp with eggs. Where do find the largest shrimp? Where do you catch the smaller ones? Where do you catch the best quality shrimp of this species? What makes one shrimp of this species better than another?

4. **Discussion of indicators in general.**

What are the signs that tell you that you will catch many shrimp next year?

What are the signs you see now that tell you that you will catch few shrimp next year?

What are the signs that tell you that this trip you will do well? do poorly?

**5. Possible indicators.**

**Number of adult females as proportion of the catch.**

Has it changed? Why has it changed? Is this good or bad? Have you ever changed your fishing as a result of the proportion of females in the catch? Do you think the number of adult females as a proportion of the catch matters to future catches? Can any change in management influence the proportion of females in the catch? Do you think that management rules should change if the proportion adult females as a proportion of the catch decreases? Increases?

**Catch per unit effort.**

Has CPUE changed? Why has CPUE changed? Is this change in CPUE good or bad? Have you ever changed your fishing as a result of a change in CPUE? Do you think that CPUE now matters to future catches? Can any change in management influence your CPUE? Do you think that management rules should change if the catch per unit effort goes down.

**Species composition.**

Has the species composition changed? Why has it changed? Is this change good or bad? Have you ever changed your fishing as a result of a change in species composition? Do you think that species composition matters to future catches? Can any change in management influence the species composition in your catch? Do you think that management rules should change if the species composition changes? How?

**Size of shrimp.**

Has the size of shrimp changed? Why has the size of the shrimp changed? Is this good or bad? Have you ever changed your fishing as a result of a change in the size of the shrimp? Do you think that the size of the shrimp matters to future catches? Can any change in management influence the size of shrimp? Do you think that management rules should change if the shrimp become smaller?

**Salinity, Rainfall, Water flow from rivers.**

Does rainfall matter to fishing How? Have you ever changed your fishing as a result of changes in the amount of rain? Do you think that rainfall matters to future catches? Do you think that management rules should change if there is more or less rain? How? Why?

**Discussion of Management.** What rules are there about fishing? For each rule ask who made the rule and who enforces the rule. After they have listed all the rules ask which rules are most often violated and why. What other rules might be good to make? Who should make them? Do you see the MoFI annual reports? Do you think they make sense? Do you know how the data are collected?

## Guidelines for Interviews with Government Officers:

## Dam Doi Shrimp Fisheries, Viet Nam

1. Please describe the shrimp life cycle beginning with where they spawn and then and where they go at what age? What is the importance of the mangrove forest for the shrimp? What is the importance of the mud flats for the shrimp.

2. Do you believe the shrimp resource is declining? Why? What are the most important indicators of shrimp abundance? How do you balance habitat causes against overfishing causes?

3. Do you believe there is any real conflict, from a purely scientific viewpoint, between aquaculture development and capture fisheries for shrimp? Why or why not? What do you believe is the proper balance between aquaculture and capture fisheries? What are the most important indicators of a good balance between aquaculture and capture fisheries?

4. Given what we have said about both the declines in the resource and its relationship to aquaculture, what do you think are the most important research priorities for shrimp management and development in Ca Mau Province?

5. What are the standard fisheries rules that apply to the shrimp resource? Mesh sizes? Zones? Banned gears? Others? What is the process for setting these rules? Is it the same process for all the rules? How can a rule be modified to fit one village or another? How has it been modified in your village?

6. Now I would like to give you a list of rules that we found and for each one I would like you to explain first the biological reasons for the rules and then the social reasons. By social reason I mean things like being able to enforce rules, how the condition of the fishers was thought about?

6a. What are the biological reasons for the 5 metre depth zone? What indicators were used in making or explain this decision? What are the social reasons for the 5 metre depth zone?

6b. What are the biological reasons for the where the river bag nets are placed? What indicators were used in making or explain this decision? What are the social reasons for the where the river bag nets are placed? How is it decided who will fish where with bag nets? We have been told that there is some disagreement between the trawl net fishers and the bag net fishers.

6c. What are the biological reasons for the ban on trammel nets? What indicators were used in making or explain this decision? What are the social reasons for the ban on trammel nets? Are there any exceptions to this ban in this village? How is it decided who will fish where with trammel nets?

6d. What are the biological reasons for the ban on push nets? What indicators were used in making or explain this decision? What are the social reasons for the ban on push nets? Are there any exceptions to this ban in this village? How is it decided who will fish where with push nets?

6e. What are the biological reasons for the mesh size regulations? What indicators were used in making or explain this decision? What are the social reasons for the mesh size regulations? Are there any exceptions to mesh size regulations in this village? How is it decided who will fish with these other mesh sizes.

7. Provincial only: do you have statistical information on the numbers of fishers of each gear and the shrimp catch.

## Appendix Two: Consensus Statements for Laos

**Statements Used in April 2001**

1. A) Most kinds of fish are found more often in the water between rocks in the rapids or B) more often in shallow water.

2. A) Pa Kot eat other fish or B) Pa Kot do not eat other fish.

3. A) It is no longer possible to catch Pa Koon or B) It is still sometimes possible to catch Pa Koon.

4. A) Many fish with wounds have been seen in recent years or B) Few fish with wounds have been seen in recent years.

5. A) Fish with wounds are mainly seen when the water level is decreasing or B) Fish with wounds are mainly seen when the water level is increasing.

6. Pa Nai A) sometimes spawn in the small streams or B) Pa Nai never spawn in the small streams.

7.A) Pa Nai eat the eggs of other fish or B) Pa Nai do not eat the eggs of other fish.

8. A) Fish that migrate up from the Mekong sometimes spawn in the small tributary streams of the Sedone or B) Fish that migrate up from the Mekong never spawn in the small tributary streams of the Sedone.

9. A) Pa Keung like to stay in rocky habitat more than other habitat or B) Pa Keung like to stay in other habitat more than rocky habitat.

10. A) Pa Lang Khon go into rice paddy fields or B) Pa Lang Knon do not go into rice paddy fields.

11.A) Most kinds of fish are found most often in the deep pools or B) Most kinds of fish are found more often in shallow water.

12. A)Pa Eeun have decreased in size and now only small ones can be seen or B) Pa Eeun have not decreased in size and large ones can still be seen.

13. A) Pa Lang Khon is most abundant in September and October or B) Pa Lang Khon is most abundant in June and July.

14. A) Pa Pawn are never caught any more or B) Pa Pawn are sometimes still caught.

15. A) Pa Wa migrate upstream in June and July or B) Pa Wa migrate upstream in September and October.

16. A) Pa Nai migrate upstream in November and December or B) Pa Nai migrate upstream in June and July.

17. A) Pa Wa spawn only in the Mekong River or B) Pa Wa sometimes spawn in the Sedone River.

18.A) Pa Keung lay eggs in the roots of trees or B) Pa Keung do not lay eggs in the roots of trees

19. A) Pa Kot are more abundant when the water is high or B) Pa Kot are more abundant when the water is low.

20. A) Pa Wa eat algae or B) Pa Wa do not algae.

21. A) Pa Wa eat small fish or B) Pa Wa do not eat small fish.

22. A) Pa Kot stay in one part of the river all year round or B) Pa Kot move up and down the river during the year.

23. A) Pa Lang Khon eat algae or B) Pa Lang Khon do not eat algae.

24. A) Pa Keung eat small fish or B) Pa Keung do not eat small fish.

25. A) It is no longer possible to catch Pa Koang or B) it is still sometimes possible to catch Pa Koang.

26. A) Pa Duk have decreased in numbers or B) Pa Duk have not decreased in numbers.

27. A) Pa Kho have decreased in numbers or B) Pa Kho have not decreased in numbers.

## Statements Used in October 2001

1. A) The water level in the Sedone has decreased compared to five years ago or B) the water level in the Sedone has not decreased compared to five years ago

2. A) Fish are more difficult to catch than five years ago or B) fish are not more difficult to catch than five years ago

3. A) Fishermen use small mesh-sizes to catch fish during the dry season and large mesh-size gillnet during the rainy season B) fishermen use the mesh-size all year round

4. A) In the last two years more white foam has appeared on the water than usual or B) in the last year the amount of white foam on the water has been normal.

5. A) The number of Pa Phia have decreased or B) the number of Pa Phia have not decreased.

6. A) The Pa Keung always spawn in the deep pools or B) the Pa Keung sometimes spawn in other places.

7. A) In the last five years the river bottom has become more covered with sand and dirt or B) in the last few years the river bottom has not become more covered with sand and dirt.

8. A) Over the past five years the number of fishers in the Sedone has increased or B) over the past five years the number of fishers has not increased.

9. Pa Keng a) spawn anyplace or B) spawn only in certain special places.

10. A) Fishers use monofilament gill nets in the last five years or B) fishers have been using monofilament for longer than five years.

11. A) In the last five years the amount of dirt the river carries has increased or B) In the last few years the amount of dirt the river carries has not increased.

12. A) In general, fish have decreased in size over the past five years or B) in general, fish are the same size now as they were five years ago.

13. Pa Keng A) sometimes spawn in the main stream of the Sedone or B) never spawn in the main stream of the Sedone.

14. A) Pa men have disappeared or B) Pa men can sometimes still be seen.

15. A) Pa saee are in the Sedone when the water level is high B) Pa saee are in the water when the water level is low.

16. A) Many fishers do not follow the rule against in the spawning areas on the small tributaries in the rainy season or B) Few fishers do not follow the rule against fishing in the spawning area on the small tributaries in the rainy season.

17. A) When the dam was built no changes could be seen in the appearance of the river or B) when the dam was built some changes were seen in the appearance of the river.

18. A) Pa mak ban are in the Sedone when the water level is high or B) Pa mak ban are in the Sedone when the water level is low.

19. The colour of the water in the dry season is basically the same as five years ago or B) the colour of the water in the dry season is quite different than it was five years ago.

20. A) We still see Pa eun dta deng of all sizes or B) Now we can only see Pa eun dta deng of small sizes.

21. A) Pa wa souang spawn in the Sedone in May or B) Pa wa souang do not spawn in the Sedone in May.

22. A)There is much more seaweed to be seen in the dry season than in the wet season or B)There is not much more seaweed in the river in the dry season than in the wet season.

23. In the past we use to have problems associated with fishers using explosive to fish A) but we no longer do B)and we still have problems with fishermen using explosive to fish

24. A) Pa lang Khon eat earth worms or B) Pa lang khon never eats earth worms.

# Appendix Three: Statements Relevant to Indicators as Used in Table 2.3.5

Water Level

October: A) The water level in the Sedone has decreased compared to five years ago or B) the water level in the Sedone has not decreased compared to five years ago

A) When the dam was built no changes could be seen in the appearance of the river or B) when the dam was built some changes were seen in the appearance of the river.

Water Quality

October: A) In the last two years more white foam has appeared on the water than usual or B) in the last year the amount of white foam on the water has been normal.

A) In the last five years the river bottom has become more covered with sand and dirt or B) in the last few years the river bottom has not become more covered with sand and dirt.

A) In the last five years the amount of dirt the river carries has increased or B) In the last few years the amount of dirt the river carries has not increased

A) The colour of the water in the dry season is basically the same as five years ago or B) the colour of the water in the dry season is quite different than it was five years ago.

Access to Spawning

October: A) The Pa Keung always spawn in the deep pools or B) the Pa Keung sometimes spawn in other places.

Pa Keng a) spawn anyplace or B) spawn only in certain special places

Pa Keng A) sometimes spawn in the main stream of the Sedone or B) never spawn in the main stream of the Sedone

A) Pa wa souang spawn in the Sedone in May or B) Pa wa souang do not spawn in the Sedone in May.

April: Pa Nai A) sometimes spawn in the small streams or B) Pa Nai never spawn in the small streams.

A) Fish that migrate up from the Mekong sometimes spawn in the small tributary streams of the Sedone or B) Fish that migrate up from the Mekong never spawn in the small tributary streams of the Sedone

A) Pa Wa spawn only in the Mekong River or B) Pa Wa sometimes spawn in the Sedone River.

A) Pa Keung lay eggs in the roots of trees or B) Pa Keung do not lay eggs in the roots of trees

Number of people fishing

October — A) Over the past five years the number of fishers in the Sedone has increased or B) over the past five years the number of fishers has not increased.

Fish Catch

October — A) Fish are more difficult to catch than five years ago or B) fish are not more difficult to catch than five years ago

A) The number of Pa Phia have decreased or B) the number of Pa Phia have not decreased.

April — A) Pa Duk have decreased in numbers or B) Pa Duk have not decreased in numbers.

A) Pa Kho have decreased in numbers or B) Pa Kho have not decreased in numbers.

Fish Size

October — A) In general, fish have decreased in size over the past five years or B) in general, fish are the same size now as they were five years ago.

A) We still see Pa eun dta deng of all sizes or B) Now we can only see Pa eun dta deng of small sizes.

April — A)Pa Eeun have decreased in size and now only small ones can be seen or B) Pa Eeun have not decreased in size and large ones can still be seen.

Species Diversity

October — A) Pa men have disappeared or B) Pa men can sometimes still be seen.

April — A) It is no longer possible to catch Pa Koon or B) It is still sometimes possible to catch Pa Koon.

A) Pa Pawn are never caught any more or B) Pa Pawn are sometimes still caught.

A) It is no longer possible to catch Pa Koang or B) it is still sometimes possible to catch Pa Koang.

# Appendix Four: Guidelines for the Biological Evaluation Interviews

Hello we are Danish fisheries experts working with the Provincial and the District management and we are trying to learn about the fish stocks that you catch around here. You may know that we have done interviews in February and again in April, but this time we would like to talk about the different signs or indicators that can help us learn about the status of the fish stocks and the environment. Would you be willing to spend some time with us answering questions and do you mind us taping the conversation?

How long have you been fishing?

Are you fishing all year round or only at certain times?

Are you mostly using gill-nets or hook/lines and traps?

Now I will ask you questions where you must choose one of three answers. Later we will discuss the questions in detail.

Is the water level of the river in the dry season: lower now than before, higher or no change?

Is your catch of fish in the main Sedone River lower now than before, higher or no change?

Is your catch of fish in the seasonal streams lower than before, higher or no change?

Have the fish you catch become smaller, larger or no change?

Can the fish get into the seasonal streams: easier now than before, harder or no change?

In this area (village) is there now: more people fishing, less people fishing or no change?

Is the water in the river: cleaner than before, dirtier than before or no change?

Is there some fish that you used to catch, that you don't catch anymore? Many, few, none?

Have the flooded areas decreased, increased or no change?

Are more fish from this village being sold now than before, fewer, no change?

Can you tell from the amount of algae on the rocks (in the dry season) if many fish are present? If yes: What species?

Can you sometimes tell from the smell of the water if many fish are present`? If yes: What species?

Do you think the water level is changing when trees are cut down?

Does the number of boats in a village show how much people fish?

Can you tell from the number of surfacing fish if many fish are present? Explain!

Can you tell from the noise some fish makes if many fish are present? Explain!

Does the use of irrigation affect the water level?

What fish species do you know to gather in the deep pools of Sedone? Do you think all of them go there or do some go other places?

# Appendix Five: Consensus Statements for Dam Doi

**Offshore Statements**

1. Offshore shrimp species stay offshore their whole lives and inshore shrimp species stay inshore their whole lives.

2. Shrimp catch composition has not changed.

3. Rainfall is does not affect the shrimp yield in the offshore area.

4. Only prawns in fresh water have visible eggs.

5. The yield of shrimp has decreased every year

6.All shrimp like to stay in transparent water.

7.Shrimp will move to shallow places when they become adult.

8. The yield of shrimp reduced suddenly last year.

9. The water temperature is gradually increasing from the coastline to offshore in the dry season.

10. Sac shrimp stay offshore from December to January.

11. The yield of some species has increased while the yield of others has reduced.

12. Normally, water temperature is low from November till January, then it starts to increased to May.

13. All shrimp breed in the off shore area.

14. Since 1986, the shrimp yield has reduced rapidly.

15. A North wind means we will catch fewer shrimp.

16. In south wind season shrimp come to stay in deep places.

17. Gay shrimp became few but now there are many more.

18. Large, adult shrimp stay in the offshore areas.

19.The Gay shrimp became very few about 4-5 years ago.

20. The shrimp that live in muddy bottoms have low value but a high yield.

21. Su shrimp brood stock live in shallow water.

22. Very few Sat shrimp are now caught.

23. Each different species will have different areas of spawning ground.

24. Chi Bong shrimp stay in inshore, shallow places. A.

25. In the past three years, the yield of Giang shrimp has reduced more than other species.

26. The salinity of sea water is highest in August and lowest in March.

27. Gay shrimp and Giang shrimp are often caught from 20- 30 nautical miles offshore, they concentrate in deep water levels during the entire year.

28. I often catch Su shrimp

29. In nature, shrimp species have the ability to tolerate large changes in salinity.

## Inshore Statements

1. Offshore shrimp species stay offshore their whole lives and inshore shrimp species stay inshore their whole lives.

2. Shrimp catch composition has not changed/

3. If shrimp live in the root of the mangrove, they will grow faster.

4. Only prawns in fresh water have visible eggs.

5. The yield of shrimp has decreased every year.

6. If the current is stronger the bottom becomes muddier, but a weak current will make the bottom sandier.

7. Shrimp move to shallow places when they become adult.

8. The yield of shrimp reduced suddenly last year.

9. The water balloon can be seen from June to August

10. Sac shrimp stay offshore from December to January.

11. The yield of some species has increased while the yield of others has reduced.

12. The fishing ground changes from place to place in the rainy season due to high water turbidity.

13. Shrimp breed in shallow places.

14. Since 1986, the shrimp yield has reduced rapidly.

15. A North wind means we will catch fewer shrimp. F.

16. The Bac shrimp has eggs from May to August.

17. The Gay shrimp had a high yield in the past , but it is much lower now.

18. When wind from the sea brings up water, shrimp in the ponds will move to the river.

19. The The shrimp became very few about 4-5 years ago.

20. The shrimp that live in muddy bottoms have low value but a high yield.

21. Dat shrimp is found most often in shallow water.

22. Very few giang shrimp are now caught.

23. Each different species will have different areas of spawning ground.

24. Chi shrimp is caught in shallow water.

25. In the past three years, the yield of Gay shrimp has reduced more than other species.

26. The salinity of sea water is highest in August and lowest in March. H

27. The natural shrimp decrease year by year.

28. In nature, shrimp species have the ability to tolerate large changes in salinity.

# Appendix Six: Statements Relevant to Indicators as Used in Tables 3.3.6 and 3.3.7

Changes in the geographical distribution of shrimp species

| | |
|---|---|
| Offshore: | Sac shrimp stay offshore from December to January. |
| | In south wind season shrimp come to stay in deep places. |
| | Large, adult shrimp stay in the offshore areas. |
| | Su shrimp brood stock live in shallow water. |
| | Chi Bong shrimp stay in inshore, shallow places. |
| Inshore: | Sac shrimp stay offshore from December to January. |
| | Dat shrimp is found most often in shallow water. |
| | Chi shrimp is caught in shallow water. |

Size of the nursery areas

| | |
|---|---|
| Offshore: | Each different species will have different areas of spawning ground. |
| Inshore: | Each different species will have different areas of spawning ground. |

Changes in Mangrove Cover

| | |
|---|---|
| Inshore: | If shrimp live in the root of the mangrove, they will grow faster. |

Temperature

| | |
|---|---|
| Offshore: | The water temperature is gradually increasing from the coastline to offshore in the dry season. |
| | Normally, water temperature is low from November till January, then it starts to increased to May. |

Wind

| | |
|---|---|
| Offshore: | A North wind means we will catch fewer shrimp. |
| Inshore: | A North wind means we will catch fewer shrimp. |

Turbidity

| | |
|---|---|
| Offshore: | All shrimp like to stay in transparent water. |

Salinity

| | |
|---|---|
| Offshore: | The salinity of sea water is highest in August and lowest in March. |
| | In nature, shrimp species have the ability to tolerate large changes in salinity. |
| Inshore: | The salinity of sea water is highest in August and lowest in March. |
| | In nature, shrimp species have the ability to tolerate large changes in salinity. |

Fecundity

Offshore: Only prawns in fresh water have visible eggs.

Inshore: Only prawns in fresh water have visible eggs.

The Bac shrimp has eggs from May to August.

Size distribution by area

Offshore: Offshore shrimp species stay offshore their whole lives and inshore shrimp species stay inshore their whole lives.

Shrimp will move to shallow places when they become adult.

Inshore: Offshore shrimp species stay offshore their whole lives and inshore shrimp species stay inshore their whole lives.

Shrimp will move to shallow places when they become adult.

When wind from the sea brings up water, shrimp in the ponds will move to the river.

Catch rates

Offshore: The yield of shrimp has decreased every year

The yield of shrimp reduced suddenly last year

Since 1986, the shrimp yield has reduced rapidly

Gay shrimp became few but now there are many more.

I often catch Su shrimp.

The Gay shrimp became very few about 4-5 years ago.

Inshore: The yield of shrimp has decreased every year

The yield of shrimp reduced suddenly last year

Gay shrimp became few but now there are many more.

Very few giang shrimp are now caught

The The shrimp became very few about 4-5 years ago.

Catch composition

Offshore: Shrimp catch composition has not changed.

The yield of some species has increased while the yield of others has reduced.

In the past three years, the yield of Giang ship has reduced more than other species.

Inshore: Shrimp catch composition has not changed.

The yield of some species has increased while the yield of others has reduced.

In the past three years, the yield of Giang ship has reduced more than other species.

## Appendix Seven: The Dam Doi Q-sort Statements

1. The yield of shrimp has dropped down due to so many fishing boats.

2. The yield of shrimp has dropped down because small boats go fishing inshore.

3. The yield of shrimp has reduced year by year because of new fishing technology.

4. The lower yield of shrimp is due to heavy rain and storm.

5. Polluted water has caused dead shrimp.

6. There are fewer natural shrimp due to loss of land with mangrove forest.

7. Shrimp production has reduced much in near shore area, because there are so many activities such as trawl net and push net.

8. You cannot predict the yield of shrimp next year from the yield this

9. No indicator can show what the production of shrimp will be next year.

10. Many water balloons are a sign that shrimp production will be high.

11. The number of different shrimp species is not important.

12. That would be good if the DOFI do not allow the fishing of shrimp brood stock in the spawning season.

13. It would be good if the DOFI did not allow the catching baby shrimp in the in shore area.

14. I think that government needs to have regulations about mesh net for each kind of boat.

15. I think that government needs to have regulations about mesh size for each fishing ground.

16. The main purpose of integrated mangrove and aquaculture model is to develop aquaculture.

17. The main purpose of integrated mangrove and aquaculture model is to help every people to recognize the role of the mangrove forest.

18. Aquaculture has been bad for natural shrimp.

19. Overfishing has reduced shrimp production.

20. There are no methods suitable for preventing shrimp disease yet.