FISHING STRATEGIES OF SMALL-SCALE FISHERS AND THEIR IMPLICATIONS FOR FISHERIES MANAGEMENT

by

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Abstract

A comparative study was undertaken to evaluate the fishing strategies of small-scale fishers from three ports in Yucatán, México. Fishers from the area exploit the same resources and are constrained by similar regulations and environmental conditions, so it could be expected that they would use similar fishing strategies. However, the results show differences among and within ports in catch profiles and strategies, which are: switching behavior, changes in fishing efficiency, and working in cooperation teams.

Although some fishers claimed to specialize in lobsters, switching behavior between alternative species was commonly observed in all three ports throughout the year. To test hypotheses associated with switching behavior, I used a discrete choice model. The results indicate that fishers' decisions were not randomly defined; resource abundance and revenues from the previous trip were significant in the selection of target species for the following trip. Differences among fishers were evident in terms of fishing efficiency and fishers' performance. In Sisal, fishers appeared to be more homogeneous than in other ports. However, in Dzilam Bravo, differences between the more efficient fishers and the 'average' were tenfold. Multiple regression analysis showed that catch rates and landed values were associated with the number of trips undertaken within a fishing season in all ports. In the other ports, fishers' experience, fishers' age, boat size, and motor power were also associated with this variation. A distinct strategy observed only in Dzilam Bravo was cooperation among fishers, where two or more fishers equally shared their catches. This strategy appears to be adopted in response to uncertain weather conditions.

To summarise the results, I present a conceptual framework that illustrates how knowledge of fishing strategies could help managers to incorporate fishers' dynamics into the design of management schemes. The results of the analyses undertaken in this study indicate that current management regulations in Yucatán could be misleading since they do not account for fishers' strategies. I stress the importance of evaluating fishers' strategies as they can provide useful information for fine-tuning models in fisheries assessment, help in the implementation of development programs in fishing communities, and provide inputs for management plans.

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CHAPTER 1

Conceptual and methodological framework

1.1. Introduction

Small-scale fisheries provide fish for direct human consumption as well as jobs for the fishing communities and adjacent areas. There are about 50 million people involved in these fisheries through catching, processing, and marketing (Williams 2000).Despite their importance, less attention is paid to small-scale fisheries than to large commercial ventures. Adaptability of fishers is particularly relevant in these fisheries, where the flexibility of gears allows fishers to target a variety of species. Hence, these conditions make it more difficult to identify the components of fishing effort applied to each specific resource.

Small-scale fishers are presented with challenges, such as limitation of the time they can spend fishing because of the weather or the type of boat or gear they use. These circumstances impose economic uncertainty on a day-to-day basis. To maintain their livelihood, fishers develop strategies, which involve each fisher in an individual decision-making process governed by their goals and constraints. Regardless of this, fisheries scientists and managers tend to focus mainly on long-term dynamics and seldom capture the rapid changes in effort resulting from the daily decisions that fishers make of when, where, and what to fish. Additionally, homogeneity of fishers is an initial assumption of fisheries scientists, or is used by managers to define stereotypes of fishers in outlining management plans. Limited attention has been given to analysis on the context of small-scale fisheries or to identify the strategies that fishers develop under particular circumstances. Furthermore, it is necessary to understand fishers' motivation, because management schemes may influence individuals and groups differently.

Using field data on small-scale fishers in the Yucatán coast, my dissertation seeks to provide insights into fishers' behavior through the analysis of their fishing strategies. I have tested several hypotheses related to the homogeneity of fishers and their switching behavior. In this sense, similarities and different features of fishers in the selected ports offer an interesting opportunity to carry out comparative studies.

In this chapter, I describe the general characteristics of small-scale fisheries, followed by a statement of the problem on which I based my thesis, and a list of the research objectives. Next, to set the context, I discuss fishing strategies and related topics. Next, I present the methodological framework that I followed in the study. Finally, I conclude with an outline of each chapter of the thesis.

1.2. Characteristics and definitions of small-scale fisheries

Among the questions that arise when we search the literature about small-scale fisheries are: "how small is small?" and, how do the small-scale fisheries differ from so-called subsistence fisheries?. Several attempts to define 'small-scale fisheries' have been made (Panayatou 1982; Russel and Poopetch 1990; McGoodwin 1990), and in some cases artisanal and small-scale fisheries are referred to as being equivalent or synonymous (Lawson and Robinson 1983; Pauly and Agüero 1992).

Russel and Poopetch (1990) declare that scale is not the only consideration to be taken into account, and that 'small' needs not always to be equated with 'artisanal', or imply boats without outboard motors. The mode of production and organizations such as family firms, co-operatives, or fishers hired by the private sector are important factors to be considered as well. Details on these aspects for my case study are presented in Chapter 2. Dependence on fishing for income and not only for subsistence turns these fisheries into commercial activities although with limited, or lack of capital commitment (see McGoodwing 1990).

While the majority of small-scale fisheries are found in developing nations, a considerable number exist in developed nations as well. Although the latter may employ more sophisticated types of fishing gear and obtain larger catches than the former, they still qualify as small-scale fisheries in terms of their capital commitment. Thus, "how small is small?" might depend on the reference point. For example, middle-scale boats in Yucatán could be equated to small-scale boats in some Canadian fisheries.

Although differences exist among small-scale fisheries in different regions of the globe, they have common characteristics that have been identified by different authors (see Lawson and Robinson 1983; McGoodwin 1990; Agüero 1992; Hoefle 1992; Knudsen 1995; Pauly 1997). These can be summarized as follows:

a) high diversity of target species captured with different types of boat and gear;
b) labor-intensive;
c) high mobility, i.e. many units landing in numerous spots along the coast;
d) seasonal use of the resources according to resource availability and other constraints (occupational pluralism);
e) operation of part-time fishers;
f) high contribution of protein in the coastal area;

g) considered as an alternative to solve problems of other areas, mainly rural, i.e. attractive source of employment;

h) small-scale capital commitment, thus with limited power to influence the fish market;

i) not connected directly to the market, i.e. with strong dependency on middlemen for commercialization; and

j) high dependency on subsidies from the government.

The characteristics described above certainly apply to the small-scale fisheries of Yucatán. The small-scale fisheries I will refer to in this study comprise a fleet motor-operated with a low level of technology used by individual fishers for commercial purposes. In Chapter 2, I describe particularly the fisheries used as a case study for this research.

Given the characteristics mentioned above and the uncertain nature of fishing as an occupation, it is clear that fisheries managers and fishers have to face a challenging task. The former, have to deal with heterogeneous groups of fishers, operating with different objectives and perspectives about the use of resource. The latter respond to different incentives and constraints that have an impact on their activities and livelihood. Kuperan and Abdullah (1994) state that successful management requires the voluntary cooperation of fishers in advancing their collective interest, at the expense of short-term private interests. My research leads me to contend that it is also important that managers understand the way fishers operate, their constraints, and goals. Charles (1995) asserts that one of the most fundamental lessons learned by fisheries scientists and managers is that fishers change their behavior to obtain knowledge of the whole system in response to regulations. Thus, a missing piece in the fisheries system has been to understand the dynamics of the users, the fishers.

1.3. Research objectives

This study aims to analyze the fishing strategies of individual small-scale fishers and identify the factors driving their behavior in the short term. It is expected that this knowledge may improve managers' understanding of fishers' behavior and enable them to incorporate this knowledge into policies and monitoring programs.

The specific objectives of the thesis are:

- to identify the fishing strategies of small-scale fishers in the short term and the factors related to particular strategies;

- to explore how knowledge about fishing strategies could help in the design of effective management schemes for small-scale fisheries.

1.4. Conceptual considerations

Laloë and Samba (1991) define fishing strategy as the probability of choosing among a given combination of gear, target species, and geographic location. But, Béné (1996) states that switching between options of gear, species, or location, is simply a change in fishers' behavior. Such changes in behavior may be called fishing tactics, and the strategy involves an internal decision-making process defined by the fisher about his constraint(s) and objective(s). Thus, the fisher's behavior is an expression of these strategies, and of the fleet dynamics when changes involve the whole fleet (see Ferraris and Samba 1992; Pelletier and Ferraris 2000).

Some fisheries models assume that fishers are homogeneous in motivation and decision-making; however, heterogeneity among captains in the use of resources has been observed in many different fisheries (Cove 1973; Smith and McKelvey 1986; Hanna and Smith 1993). Hence, the simple assumption that vessels will tend to equalize catch per boat disregards their individual contribution to the dynamics of the fleet. That is, individual variation can affect the distribution of catches and profits, because fishers have different incentives to go fishing and to expand their activities (Eales and Wilen 1986).

Hilborn and Walters (1992) identifies four important components of the dynamics of the fleet: a) investment, b) allocation of fishing effort, c) harvesting efficiency, and d) discarding. These elements are also important where individuals are considered. In this section, I present three of these elements providing a brief review of concepts and examples with emphasis on: allocation of the fishing effort, harvesting efficiency and its relationship with fishing strategies and individual behavior. I also introduce the concept of occupational pluralism and opportunity costs as relevant concepts associated with the small-scale fishers' strategies.

1.4.1. Fishing tactics, strategies and individual variation

Allocation of fishing effort by fishers

Fishers develop strategies in order to cope with the variability in resource productivity, regulations, and market variability, etc. The expected benefits can be defined in terms of different currencies such as money, prestige, or other personal targets. The strategies can be defined in different ways, and modified when they no longer prove to be rewarding.

Regulations are the first constraint fishers must deal with. Thus, if the number of vessels or fishers is limited, the remaining fishers can respond by changing other factors (see Wilen 1979; Palmer and Sinclair 1996; Dorn 1997). These can range from switching fisheries or target species, to increasing the duration of the trip in order to maintain benefits from the fishery. For example, where fish is processed on board, it is important that fishers make optimal use of their catches to feed the production line, such as in trawl and seine fisheries catching Pacific hake (Dorn 1997). Fishers must consider the capacity of the boat as well as the production line to decide whether or not to continue fishing. Dorn (1997) developed a Markov decision model to investigate the changes in fishing strategies when trawling at night was banned. He found that vessels adjusted their fishing time during the day, in response to changes in the mean and variance of catch levels at night, showing the flexibility of the fishers whose revenues were not reduced by the ban.

Most available information that relates to allocation of fishing effort concentrates on the spatial distribution of the fleet (see for example Hilborn and Walters 1987; Defeo *et al.* 1991; Healey and Morris 1992; Sampson 1994; Cabrera and Defeo 1997; Walters and Bonfil 1999). Selection of target species, on the other hand, has been less studied (see Opaluch and Bockstael 1994; Begossi 1992; Jenning and Polunin 1996).

Eales and Wilen (1986) suggest that a large portion of the real economic rent of a fishery may be dissipated owing to inefficient selection of target species. Thus, fishing effort would be more a reflection of expansion of effort, while searching for certain species, than an actual increase in the number of boats. Over time, more efficient strategies can evolve through learning processes. Despite this, the response of fishers to changes in the profitability of species, or shifts in targeting has been less explored than the spatial behavior of the fleet and fleet capitalization.

Sampson (1991) states that selection of fishing locations largely determines the species mix and catch value, because the travel costs and the species targeted determine the profitability of the fishing trip. On the other hand, Begossi (1992) proposes that fishing strategies differ according to the species fishers are looking for. He found that the number of patches, and the time fishers in Brazil spent in a patch, often depended on the species they targeted. Given imperfect information it can be assumed that fishers will distribute their fishing effort in areas where they expect to maximize their profits and will spend only a portion of it on exploration (see Hilborn and Walters 1987).

Specialist or generalist fishers

According to Smith and McKelvey (1986), there are two types of groups of fishers: specialists and generalists. They differ in terms of the perspectives they have regarding the fishery and their flexibility to adjust to fluctuating and uncertain conditions. The former exploits only one stock (shrimp boats for example), while the generalist fleet may switch to alternative species (trawl boats for example). Specialists cannot exceed the level of capital that they have built up; generalists on the other hand, are assumed to be more flexible, as they can absorb perturbations in activity and environmental conditions. Specialists develop skills to do well consistently in one fishery while generalists, being flexible, can shift fisheries or even move out of fishing. As specialists prefer stability, they try to minimize costs of switching between activities. Generalists accept risky conditions through maintaining a range of options.

Observations of fisheries in different regions indicate that fishers are not homogeneous and different types of fishers can operate in the same area. For example, in the salmon seine fishery in British Columbia, Hilborn and Ledbetter (1985) found that to maximize their catch within a season, fishers could develop two types of strategies: area specialization and movement specialization. In contrast, within the troll salmon fishery in B.C, Abrahams and Healy (1990) found no clear evidence of area or movement specialist as discrete strategies. The area specialist were no better fishing in the grounds were the movement specialist operated; but the reverse was true. The authors suggest that this might be because movement patterns are tied to the skippers' behavior. Pálsson and Durrenberg (1982) identify specialization patterns by gear among Icelandic skippers; some of them seemed to be better with lines than with nets, others were better with nets, while others were good with both gear types.

Specialization has also been seen as a strategy fishers use to maximize catches (see Hilborn 1985). In the examples presented by Pálsson and Durrenberg (1982), although they do not address the differences in fishing efficiency (as they give more emphasis to test the 'skipper effect'), these were clear, for instance those fishers who used nets obtained higher catches than those who used lines. A contrasting example was observed in Brazil (Begossi 1996) where fishers who used lines were more efficient than those who used nets. In both studies, efficiency was evaluated only in terms of catch. In both, it is not clear, how fishers perceived efficiency and the authors do not address the issue. Furthermore, other factors, besides increasing efficiency may be related to the decision to specialize in a particular gear or fishing method.

Area specialization has also been reported for Pacific cod and associated species caught between mainland British Columbia and the Queen Charlotte Islands (Gillis *et al.* 1993). Walters and Bonfil (1999), however, report that multispecies trawl fisheries that harvest an array of species have limited capability to target particular stocks through selection of trawl depth and location. What can be seen as area specialization by Gillis *et al.* might actually result from the spatial redistribution of the fishing effort once the catch in more profitable fishing grounds declines. Changes in fishing effort can generate a response in the fish populations, and hence in the composition of the catch in the long term producing a modification of the fisher' behavior in order to maintain their profits.

Similarly, Allen and McGlade (1986) identified two types of fishers: 'high-risk takers' or 'stochasts', and 'cartesian' or 'followers'. The former specialize in 'discovery' while the latter, as low-risk takers, only go to the locations where present information tells them that the higher returns can be found. Information is exchanged between the two types of fishers. The authors state that both types of behavior are necessary for the long-term sustainability of the fishery, the survival of an individual, and the success of the groups. Thus, under limited fluctuations of environmental and economic conditions, optimal policies could rely on efficient specialist vessels. In contrast, in a fluctuating world, the mix of generalist and specialist plays an important role in how fishers cope with variability (see McKelvey 1983; Smith and McKelvey 1986). In San Felipe, one of the ports analyzed in this study, some fishers claim to specialize in lobster, as they consider themselves good divers, yet my work shows that most of them are generalists.

Fishing strategies that provide the stability required for specialists often involve territoriality. Formal or informal arrangements are needed for this condition to be set. Examples of local tenure have been reported by Acheson (1996) in the case of the American lobster in the Gulf of Maine (USA), and spiny lobster (Seijo and Fuentes 1989) in the Mexican Caribbean (Punta Allen). Informal norms concerning territoriality restrict access to certain areas. Technological and political factors operating in each case produce differences in the territories described. Nevertheless, in both cases informal property rights are defined by members of the community. Thus, territories can be rented if they are not used, (Gulf of Maine) or even included in the fishers' will (Punta Allen).

In the Yucatan coast, several fishing co-operatives have right to catch lobster. Exclusive fishing areas have been defined according to these concessions for each group. Under these conditions, formal and informal regulations operate for the use of the areas, restricting access to outsiders but with limited control for local people. This control is enforced more in some places, like San Felipe, than in others (Sisal for example). For example, some fishers in San Felipe have proposed the establishment of Marine Protected Areas (MPAs) for management purposes in this region, yet this proposal has not advanced far (Torres per. Comm 1998).

Cooperation

Gatewood (1984b) states that human sociability is a process of negotiation in which individuals cooperate and/or compete with one another while pursuing diverse goals. He states that only under certain conditions would an individual be motivated to participate fully in a collective action. Fisheries have mainly been characterized by their competitive nature (Andersen 1973; Palmer 1990, Hart and Pitcher 1998). Thus, it can be expected that cooperation will occur only when it is mutually beneficial. Guttman (1996) suggests that the level of cooperation is relatively high where geographical mobility is relative low because it defines the alternatives fishers have and may influences their decisions.

The benefits of cooperation are not 'additive', but there is a synergistic action where the total effect is greater than the sum of the independent actions (Guttman 1996). If this synergism can be obtained, why does not everyone cooperate? Some scientists argue that lack of information and the need to maintain control of their own activities has implications for the choices fishers make regarding cooperation. Fishers may perceive the potential benefits that cooperation could provide, but at the same time, they may want to maintain their sense of independence. For example, Alaska seiners may want to project outwardly that they can handle things by themselves, even if they recognize the potential benefits of cooperating with others (Gatewood 1984b).

Cooperation among fishers has different forms. One of the most common is related to information sharing (see, Gatewood 1984b; Palmer 1990), while others either share their catches (see Begossi 1996; Ruttan 1998) or do both (Blondin *et al.* 1981). Changes in conditions in the fishery may change the details of the cooperative effort. For example, Alaska seiners share information on a regular basis, but when quotas are defined, it is difficult to negotiate a cooperative effort because each fisher wants his own quota. A contrasting situation, however, is observed in Brazil, where fishers seem to maintain informal reciprocity in long-term alliances. In most of the cases fishers fish with a brother, thus kinship appears to be important in the definition of the alliances. In this regard, the size of the groups appears to be important for the interaction patterns and communication. This is relevant in the sense that the fewer the people in the group they share information, the easier to develop trusts. Blondin *et al.* (1981) report that fishes in Yucatán cooperated when using seine nets to fish small pelagic fish, because of the length of the nets did not permit them to be operated only by one boat. Although it is not very clear under what circumstances people co-operate, sharing catch and information appear to be important.

Several examples in fisheries could suggest that cooperation does not always operate within the framework of reciprocal altruism. For example, in the Trochus fishery in Ohoirenan, Indonesia, relations between groups are governed by what Ruttan (1998) defines as an asymmetric altruism. Given a large village size, cooperation operates among the members of the village council and/or among the heads of the central families. Usually they have the final say in the management decisions and obtain the largest revenues from the sale of the catches. Norms and ideology strongly reinforce cooperation. Furthermore, social relationships are also important for maintaining ties with other members of the community and in some cases may drive the rules of cooperation and interaction (Ruttan 1998).

Harvesting efficiency

Harvesting efficiency is one of the most studied areas in fleet dynamics. The ultimate objective of these types of studies is to determine how fish abundance and effort affect the catch (Hilborn 1985), especially in those cases where catch per unit of effort (CPUE) is used in stock assessment. According to Hilborn and Walters (1992), two main approaches have emerged: a statistical approach and a functional approach. The former shows the relationship between vessel attributes, such as fishing power of the boat and catch level (usually by multiple regression). In some cases good correlation have been found (Pálsson and Durrenberg 1982) but in other cases little or none has been shown (Haywood and Haley 1976; Hilborn and Ledbetter 1985). In the latter, 'skipper effect', i.e., the relationship between skipper experience and fishing success, has been considered a relevant factor in determining catch rates when the vessel's attributes seem to be irrelevant (Hilborn and Ledbetter 1985).

The functional approach, on the other hand, focuses on the components of the harvesting process and its effect on catch rates. Among these elements, Hilborn and Walters (1992) include time spent in different activities, density of the fish in the searched area, and gear attributes. This approach allows one to consider vessel attributes, but also fishers' decisions based on their knowledge of fish behavior (Paloheimo and Dickie 1964). Handling time and how it can be affected by changes in technology can also be incorporated (Hilborn and Walters 1992). Hilborn and Walters assert that this type of analysis has been less applied than the statistical one, possibly because it requires more information, including on-board observers.

There are many anthropological accounts of folk models of fishing success. This has been attributed to skills of captains or fishing tactics of leaders of the fishing operations (see Cove 1973; Gatewood 1984b; Acheson 1996). Pálsson and Durrenberg (1982) however, contend that the 'skipper effect' is a myth. They state that, like other folk concepts, it has not been rigorously tested, and that the use of electronic aids to fishing and navigating (sonar, LORAN, radar etc.) have reduced the skipper effect. Thus, the reasons for success or failure among skippers are merely differences in the size of their boats and/or the frequency of their trips.

Knowledge of fishers about fish distribution and the characteristics of their boats could be important in understanding differences in catch rates observed between vessels. For example, Abraham and Healey (1990) found a difference of 3.6 between the average catches of 'top ranked' vessels and the 'bottom ranked' regardless fishing in the same area at the same time. Size and mobility of the vessels as well as time spent in each area seem to be important in defining the differences. However, the authors assert that movement patterns are tied to skippers' decision and that this involves knowledge of fish behavior. In the same line, Portier *et al.* (1997) emphasize that the use of fishing attractive devices (FADs) concentrate fish in the Java purse seine fishery make it particularly difficult to estimate effective fishing effort and fishing mortality. However, purse seiners seem to cooperate and they search for fish using knowledge of their seasonal migrations. During the day, fishers look for concentrations which they can catch at night.

There are different forms in which one can conceptualize efficiency. This has been reported in several ways, and evaluated using different outputs (catch, money, and prestige) for different types of analysis. These outputs are not always independent. For example, an efficient fisher can be seen as a successful captain who then recruit better crew, who also catch more. Thus, in the long term, prestige and financial rewards could be mutually reinforced (Gatewood 1984a; Cove 1993). Hence, efficiency can be defined in terms of an input-outcome process in which the units can be defined depending on what the fishers are trying to achieve. In Yucatán, efficient fishers can be those that consistently bring large catches to port. However, fishers also obtain prestige by fishing for species such like shark or lobster, which require special skills, and small catches can yield high economic rewards.

1.4.2. Investment and individual variation

The widespread idea that most major fisheries problems are at least partially caused by over-investment is well acknowledged (Wilen 1979; McGoodwing 1990; Hilborn and Walters 1992). It is often unknown how many vessels operate in a fishery, especially where fishers use the same gear and vessel to fish alternative species. Most small-scale fisheries fall into this category, thus it is more difficult to identify the participation of capital and labor in these fisheries. In spite of this, little work has been done on the subject (Charles 1983; Lane 1988; Sampson 1992; Munro 1998).

From their expectations, and subject to the conditions of the fishing enterprises and individual context, fishers are assumed to make rational decisions to define their investments. Lane (1988) states that insights about the key factors involved in decisions of how fishers invest their money and time could provide the basis for developing policies that anticipate fishers' response patterns. Hilborn (1985) argues that, in many fisheries external factors such as access to alternative fisheries and subsidies may have an important effect on investment, so this is related weakly to profitability. This pattern is observed commonly in small-scale fisheries. In this regard, it is also important to evaluate the opportunity cost of labor, as it would enable fishers to decide how to invest their time given their constraints and alternative sources of income.

Some scientists have developed simulation models to explain the dynamics of the fishers in the short and long term. The general assumption in short term models is that if population biomass remains constant and the fishers operate anywhere, they will keep investing time and capital, provided returns exceed operating costs (Lane 1988; Sampson 1991; 1992). Long-term models assume that vessel owners expect a positive net benefit from their investment; if they do not get it, they could sell their ships and recover part of the investment (Sampson 1991; 1992). Another option would be to put the vessel into another activity (Sampson 1992). Munro (1998) states that rational fishers would collectively have an incentive to invest in 'conventional capital' (for example boats) well beyond the optimal, as long as they have no restricted access to the resources. Once the investment had been made, if 'conventional capital' is not malleable, it is not easy to deal with problems of overcapitalization. He also states that is not appropriate to examine the management of one fishery in isolation, as removal of capital from one fishery could affect others. High variability of the income and malleability of the boats may define the level of risk fishers are willing to assume when investing or re-directing the use of their capital or labor.

In a model that incorporates fishers' behavior to analyze long-term policies, Lane (1988) found that individual fishers behave as independent decision-makers operating in a competitive environment. As such, the collective action of independent operators does not imply that the welfare of all fishers is maximized simultaneously by this action. He elaborates about the 'prisoners dilemma', which is that, in the short term, fishers invest in a competitive environment to improve their own position, without considering the collective economic welfare. However, in the long term they wish to maintain the fishing resource for their own benefit.

Investment needs to be addressed not only in terms of monetary capital, but also in terms of human capital. For instance, positive non-monetary rewards (working alone, status, and independence) can also motivate fishers to remain in the activity when purely economic models predict that fishers would quit fishing. Thus is important to recall that fishing is not just an economic activity, but that it also defines the way of living for many people, especially in the case of small-scale fisheries.

1.4.3. Fishing as an occupation

Implicit in many fisheries it is the assumption that fishers ignore both, the long-term and the collective effect of their actions on the resource when trying to maximize their profits in the short term. However, social scientists argue that this does not hold for fishers with strong cultural and ethnic identities; that is, money is not the only driving force behind them (Hanna and Smith 1993; Jacobson and Thomson 1993; Sinclair *et al.* 1999). Many fishers are distinguished by a strong attachment to the fishery because job satisfaction and community attachment are also important in defining them as fishers. Several studies have demonstrated heterogeneity among commercial fishers in the degree of 'goals' and fishers' practices (Cove 1973; Apostole *et al.* 1985; Thiessen and Davis 1988; Gatewood and McCay 1990; Hanna and Smith 1993).

Even though it has been commonly assumed that fishers want to maximize profits (Andersen 1982; Lane 1988), it has been observed that some fishers may quit fishing once they have achieved their 'personal target' for food or income levels, even when they are allowed to continue (see Hilborn and Walters 1992; Aswani 1998). Other factors besides the maximization of profits could affect the decision about how large a harvest to aim for. For example, in some fisheries in British Columbia and other provinces, fishers must accumulate a certain number of fishing days to qualify for unemployment insurance (Hilborn and Walters 1992). In some co-operatives in Mexico, in San Felipe (Yucatán), fishers must achieve a monthly target catch in order to keep their membership in the co-operative. Such factors can influence the way fishers operate; as emphasized by Aswani (1998) human behavior is conditional and dynamic.

There are some cases where fishing tends to be an occupation characterized by a higher degree of exclusive dependence than in other areas. The perception of fishers about access to resources could be attributed to differences in the physical environment where the captains work. For example, Apostole *et al.* (1985) state that almost 75% of the fishers interviewed in some areas of Maine derived their income only from fishing. They found that, even though forestry could be considered as a supplement to fishing in the area, this activity was actually not accessible to the fishers. Hanna and Smith (1993) report that fishers from Astoria (Oregon trawl fishery), who have to cross the Columbia river to get to their fishing grounds are limited by severe restrictions on the number of days they can fish. That is, lack of alternative employment within the fishing area or elsewhere can also define the stability of fishers in the villages (see Apostle *et al.* 1985).

Unity of fishers regarding sustainability of the fisheries to maintain their livelihood may not always operate in all cases, as fishers' perception can vary depending on their interest and circumstances. Ruttan (1998) argues that even though some fishers could genuinely be interested in conservation strategies, others may not behave altruistically. She presents the case of the Trochus fishery in Ohoirenan, Indonesia, pointing out that local fishing regulations centralized by the council could result in exclusive access for a group of people rather than concern for conservation issues.

Looking at fishing as an occupation and a way to live, we can wonder, what brings people into fishing? How are they recruited in an activity that at times can become highly uncertain? Miller and Maanen (1979) find that high income is responsible for maintaining a fisher in the fishing activity, but this may or may not have been what brought him to fishing in the first place. They observe that people 'discover' they have been born into a fishing family and cannot easily avoid learning about the occupation and working on it. Pollnac and Poggie (1978) suggest that a positive relation to the work is strong in fishers who entered the fishery at early age. This may reflect either "early socialization of the occupation of fishing" or the lack of "opportunity to compare fishing with other occupations". Thiessen and Davis (1988), argue that for fishers the value of control and independence appears to be the base of their attachment to the activity as an occupation. They state that although returns from commercial fisheries in Atlantic Canada are insufficient relative to participation and household, many people still pursue fishing as primary occupation, especially for the inshore fishers. However, uncertainty in fishing activity given environmental conditions, market and regulations may persuade fishers to search for alternative options or encourage young people to do so. In this regard, opportunity costs (the next best option of employment fishers have) could vary among fishers depending on the market value of their skills and how flexible they are about what they do and what they are willing to work on.

The level of organization of communities, occupational pluralism, the perception of risk, and the attitudes of fishers toward conservation of the resources are additional factors to consider when looking at fishers' response to changes in environmental conditions and management (see Jentof and Davis 1993; Palmer and Sinclair 1996). Although in my work I do not explore these aspects in depth. I consider it important to bring into context as they can provide some insights to understanding fishers' behavior.

Summary

Fishers are comprise heterogeneous groups, expressing of a range of behaviors. The expected benefits of the strategies they develop could be measured in different ways such as money, prestige, or other personal targets, and projected over different time-frame. Different elements define fishers' behavior in an economic activity that also defines who they are and under what circumstances they operate in order to maintain their livelihood. Individuals develop strategies as an adaptive response to a set of conditions, such as uncertainty in the abundance of the resources, environmental conditions, and market constraints. Thus, fishers will make their decisions reflecting their individual circumstances and the expected benefits for their actions. In my work I explore some of the elements that define fishing strategies in Yucatán and compare three case studies in order to better understand the dynamics of these small-scale fisheries.

1.5. Methodological framework.

This research is based on case studies conducted at three ports in Yucatán, México. In addressing the problem, I have followed the methodological framework presented in Figure 1.1.

I used daily and monthly catch data obtained from fishers logbooks of the co-operatives that fishers belong to. These records include two fishing seasons (1992 and 1993). Additionally, I gathered economic and meteorological information for the same period. The information was obtained from diverse sources such as the Ministry of Fisheries, fishing co-operatives of the studied ports, and meteorological and research centers. The information allowed me to observe monthly and daily fishing patterns and to identify the fishers' strategies in each port. I used non-parametric statistical tests (NPST) to compare these patterns among and within ports. From the three main strategies identified, I analyzed two of them in depth in order to explore associated factors: changing fishing efficiency and switching behavior.

From the distribution of the catches, I estimated an index to define fishers' performance and applied NPST to compare the fishing profiles of each port. Additionally, I used multiple regression analysis (MRA) to test several hypotheses about the potential contribution of different variables to variation in catch rates and landed value. Transformations of some of the variables were required before I performed the regression analysis, as the data did not conform to a normal distribution.

I analyzed the patterns of fishers in switching targets to alternative species using a discrete choice model (DCHM) through logistic regression analysis (LRA). For that purpose, I used information coming from a survey undertaken in 1994 based on interviews of fishers on a daily basis during August in the ports analyzed. This survey forms part of a research project run by the Centro de Investigacion y Estudios Avanzados (CINVESTAV) in which I participated during the initial stage. This included interview with every fisher and the use of diaries from selected fishers, who kept daily records of their activities. One technician from CINVESTAV remained in each port during the whole month to cross-validate the information provided each day. In Chapter 5, I provide more detail of the type of information gathered from this survey. I also use daily catch data from logbooks to validate the model. The analysis allowed me to estimate the probability of fishers selecting particular target species, and to identify the variables involved in the daily decision-making process. Finally, I integrated the results of the strategies identified and the factors associated to explore the management implications in the context of small-scale fisheries.

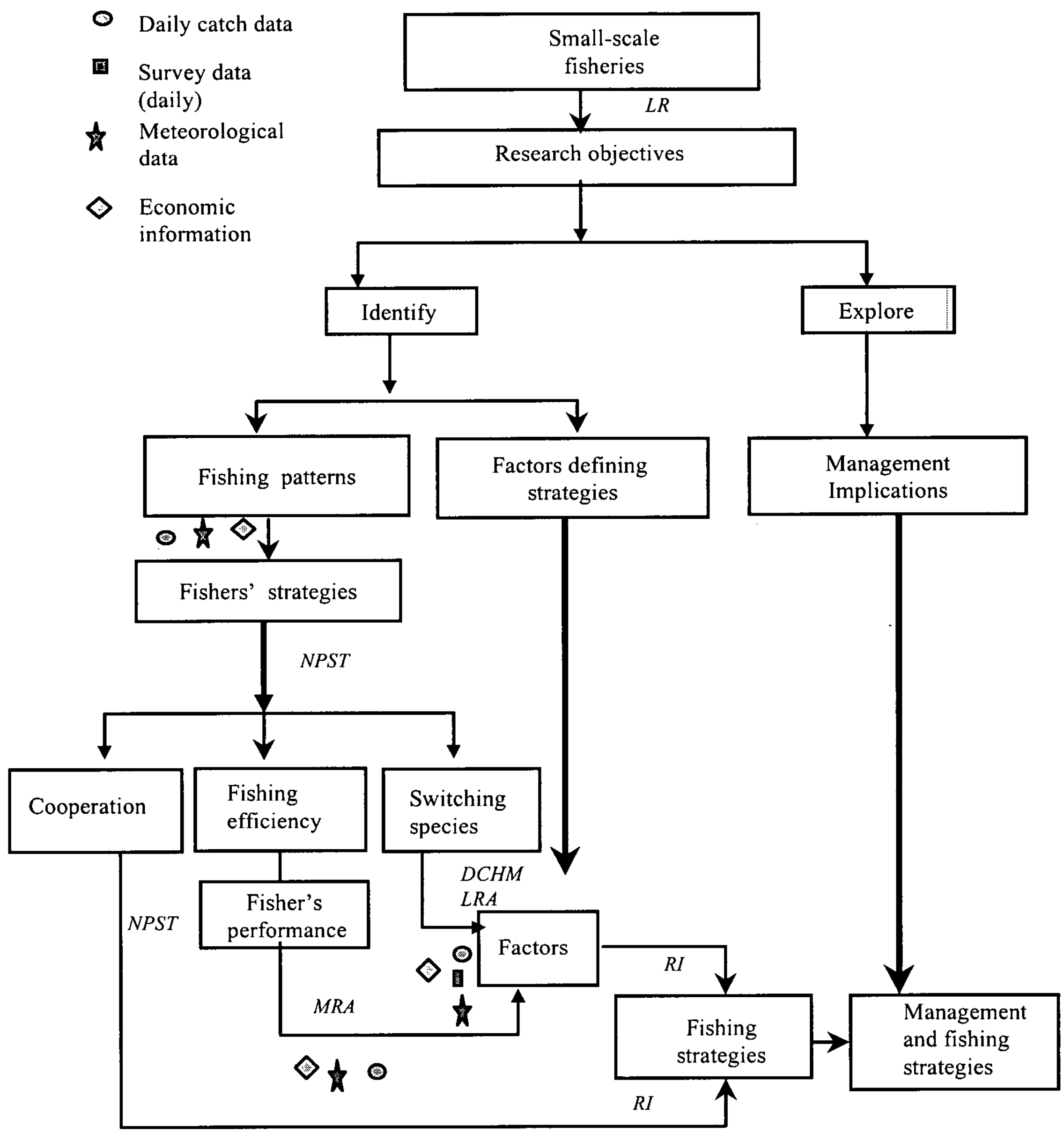

Figure 1.1. Methodological framework used in the study of Yucatán fishers' strategies. Symbols represent the sources of data used in the analyses. Labels between boxes indicate the methods employed in each case: LR = literature review, NPST = Non-parametric statistical tests, MRA = multiple regression analysis, DCHM = decision choice model, LRA = logistic regression analysis, RI= Results integration. Thicker arrows connect the main research objectives of the study.

1.6. Thesis outline

Following this introductory chapter, in Chapter 2, I present an overview of the fisheries of the Yucatán coast used as a case study. This includes information about fishing resources, markets, management regulations and the fishing communities. I refer to information from this chapter throughout the thesis. In Chapter 3, I identify the fishing strategies of small-scale fishers and compare fishers both between and within ports to address the question of homogeneity of fishers who share common characteristics. In Chapter 4, in order to evaluate the variables that may define fishers' catches and profits, I use multiple regression analysis and develop an index of fishing performance undertaken a comparative analysis of the seasonal patterns between ports using this index. In Chapter 5, I present a discrete choice model and logistic regression analyses to explore individual decision-making of fishers when targeting alternative target species. In Chapter 6, I integrate the results from previous chapters, leading to a summary of fishing strategies, an evaluation of constraints faced by fishers, and perceived fishers' goals. Finally, I discuss how the knowledge gained in this research could help in the definition of management schemes for small-scale fisheries.

CHAPTER 2

The small-scale fisheries of Yucatán

In order to give an overview of the small-scale fisheries of the Yucatán coast, I describe 1) the status of the three main fishing resources, i.e. grouper, octopus, and lobster; 2) the fishing methods used in the region to those resources; 3) management regulations, and 4) general information on socio-economics and marketing. This is followed by descriptions of fishers and the fishing communities in the three ports chosen for this study, namely, Sisal, Dzilam Bravo and San Felipe (Figure 2.1).

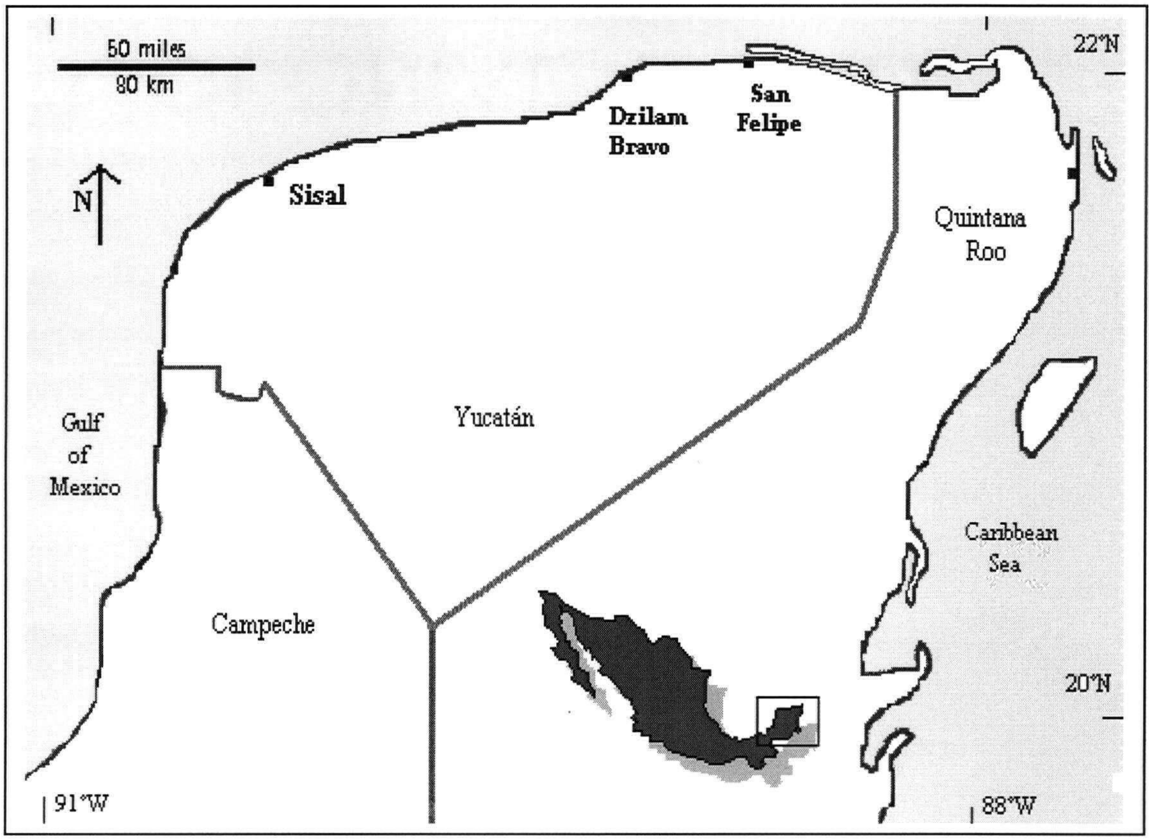

Figure 2.1. Yucatán State, México, study area.

2.1. General characteristics of the fisheries

Yucatán State is one of the most important fishing areas in México where demersal species are caught. According to the Secretaria del Medio Ambiente, Recursos Naturales, y Pesca (SEMARNAP i.e. Ministry of Environment Natural Resources, and Fisheries), the fleet in this State represented in 1998 around 60% of the national fleet fishing those resources. The annual average catch in the last 5 years in Yucatán reached about 45,000 tonnes, with a value of more than US $75 million.

Approximately 50 marine species are captured off the Yucatán coast (Chavez 1994), yet by 1998 between 50 to 60% of the landings consisted mainly of two species: red grouper (*Ephinephelus morio*) and octopus (*Octopus maya*). These species represent a value of US $35 million per year (Castro *et al.* unpublished. doc.). Another important resource is the spiny lobster (*Panulirus argus*). Even though its landings by weight are not high (1%), this species makes an important economic contribution because of its high price on the international market. For example, in 1999 the lobster price was US $25 per kg., while octopus and grouper prices were about US $4-6 per kg. Other species caught in the region are pelagic and demersal fishes, as well as some species of sharks. Most of these species are captured in shallow waters by small boats (less than 12 meters in length) with a storage capacity between 100 and 150 kg, generally making fishing trips on a daily basis. Industrial boats (15 meters in length and larger) also fish in the area. They fish in deeper waters and are able to make longer trips (from 7 to 15 days). Of the 4,000 vessels registered in Yucatán in 1997, 85% were small boats (Salas and Torres 1997). Besides the small-scale and industrial Mexican fleets, an industrial fleet from Cuba catches groupers through a bi-national agreement. The Cuban quota was set at 10,000 tonnes in 1975, and reduced to 3,900 tonnes in 1987 (see Contreras *et al.* 1993). Afterwards, this quota was reduced to 2,000 tonnes in 1998 on the basis of clear reduction in the catches of the Mexican fleet (Monroy 1998).

2.1.1. Fishing methods

The small-scale fisheries studied in this research are labor-intensive, with little mechanized power. They operate mainly on a daily basis and are commercially oriented rather than solely for subsistence. Although two of the species analyzed in this study are also caught by the industrial fleet, adaptations for this fleet are not discussed here. I will refer in this section only to the methods used by the small boats.

Demersal fish like grouper are caught with long-lines; fishers use between 1 to 4 hooks per line; they can place about 50-100 hooks per boat. Some fishers use a hand-winch to retrieve the line (Contreras *et al.* 1983). Both grouper and octopus fishing vessels carry one or two small boats (3-5 meters) called 'alijos' or 'panguita' that increase both the operation area and efficiency.

In the 1960's octopus were captured in submerged clay pots, which were tethered with lines and were used as a refuge by these animals. Other types of objects such as shells were used for the same purposes, but did not work as well. Since the 1970s, 'jimbas', a rod-and-line technique, have replaced the pots. Lines are suspended from bamboo sticks of approximately two to three meters, with several lines baited with crabs (Figure 2.2). Fishing operations are conducted from single boats and the 'alijos'. Each boat can operate between 15 to 25 lines while the 'alijo' uses around 8. This fishing method is passive, as the bait is hung in front of the octopus refuges as the boat drifts along the coast (see Solis 1967; 1987).

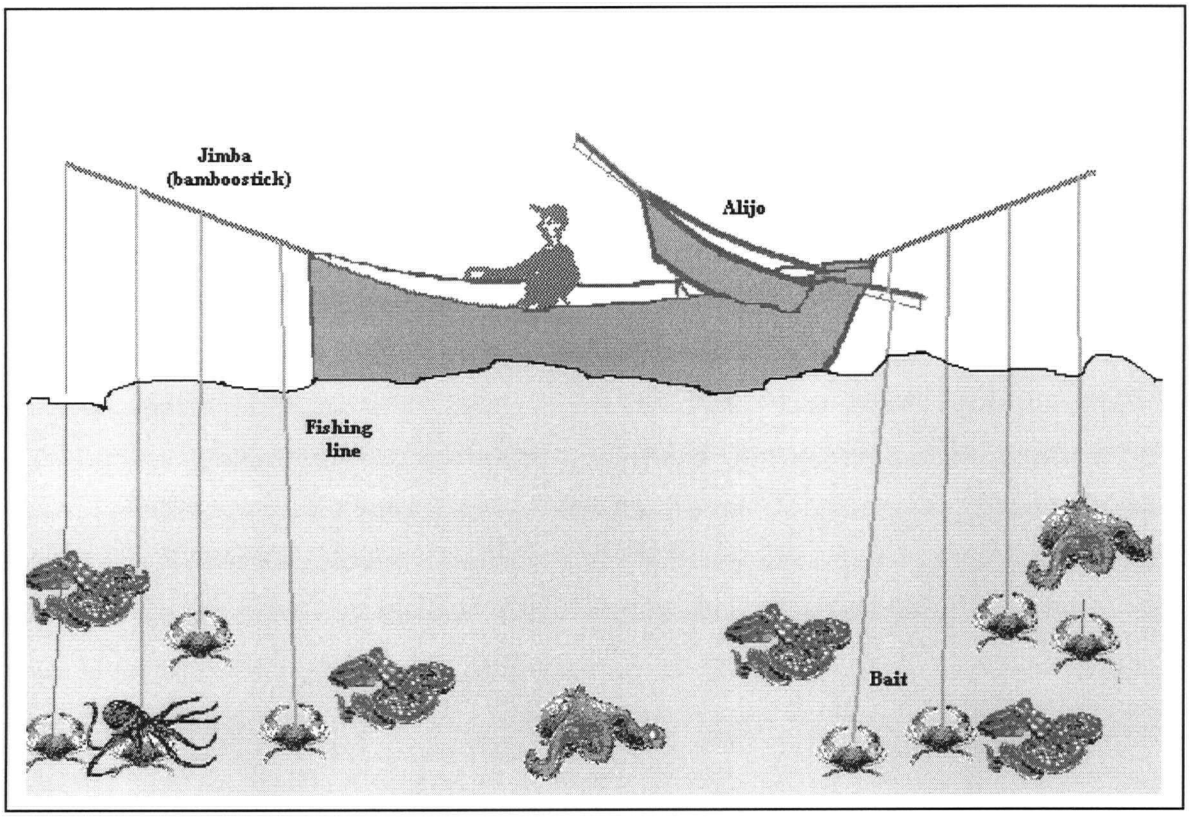

Figure 2.2. Use of 'jimbas' as fishing method to capture octopus in Yucatán, México. Fishers also carry a small boat call 'alijo' to increase their searching area.

Spiny lobster has been exploited in other regions of México by means of various types of fishing methods such as traps, nets, scuba, 'hookah', and artificial habitats (Seijo *et al.* 1991). In Yucatán, diving with 'hookah' is still the most common method. The 'hookah' system, in contrast to scuba, can allow long periods of time diving as it involves the use of an air-compressor to provide air through a hose to the diver. The hose length varies from 70 to 100 meters permitting fishers to search wide areas. The animals are extracted from their refuges with a hook. Traps have been used occasionally, but not with satisfactory results. Artificial habitats ('casitas cubanas') were introduced in 1992 in some ports such as San Felipe, Rio Lagartos and Sisal, in an attempt to develop the fishery on the Yucatán coast. They were also intended to provide alternative fishing methods to the 'hookah' to reduce the risk of compression sickness for fishers (see Torres and Salas 1993). However, it has been observed that fishing on the artificial habitats occurs only at the opening of the fishing season to take advantage of the lobster concentrations after the closed season. Afterwards, fishers seem to prefer searching for lobsters in natural habitats using the 'hookah' method (Torres and Salas 1993; Ríos *et al.* 1995). Low water temperature and turbulence have been reported as factors limiting diving. It seems that factors that are unfavorable for lobster can be favorable for catching octopus (Salas *et al.* 1991).

2.1.2. Main fishing resources: characteristics and status

Grouper

Red grouper is a gregarious and territorial species that forms seasonal reproductive aggregations. Several authors have suggested synchrony of these patterns with environmental factors (Arreguín-Sánchez 1992; Hernández 1995). An important part of the fishing operations of the industrial fleet is related to the winter spawning aggregations in the north-east of the Peninsula (Burgos and Pérez 1992; Arreguín-Sánchez 1992; Hernández 1995).

As mentioned earlier, three fleets target grouper. The main differences are in the size of the fishes caught; juveniles and young are targeted mainly by the small-scale fleet. Although attempts to evaluate the overlap of the fleets have been made (Moreno *et al.* 1991; Arreguín-Sánchez *et al.* 1997), precise identification was not possible owing to variation in the distribution of the stock and changes in the reproductive aggregations. Moreover, technological characteristics of each fleet and the spatial distribution of the resource in time and space have been lacking, especially in the case of the small-scale fleet. These conditions have limited the understanding of the fleet dynamics and consequently its impact on the resource

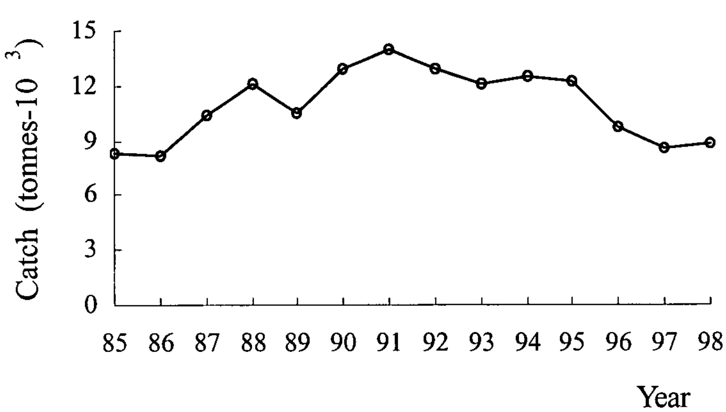

Figure 2.3. Trend of grouper catches in the Yucatán coast from 1985 to 1998.

As can be seen in Figure 2.3, grouper catches have fluctuated between 8,000 and 14,000 tonnes, from 1985 to 1998. One-third of this amount corresponds to the small-scale fleet. In the 1970's, catches reached almost 20,000 tonnes (Monroy 1998). Subsequently a reduction of almost 50% in the usual catch was observed in only a decade. Additionally, an increase in the length of the trips for the industrial fleet from 10 to 17 days was reported in the same period (Burgos and Lope 1987, cited by Monroy 1998). Reduction in the catch per unit of effort (CPUE) in the small-scale fleet has also been observed (Cabrera 1997). Monroy (1998) using a bio-economic analysis of both fleets shows the present problems of overcapacity and economic inefficiency.

From mid 1980's to the beginning of the 1990's, different studies assessing the grouper stock have indicated the risk of overfishing. Some of them suggest that the drop in the catch was probably caused by high pressure on juveniles by the small-scale fleet (Seijo 1986; Contreras *et al.* 1993). Other studies suggest that fishing pressure was mainly an additional factor that affected the population after an oil spill that occurred in 1980 in the Campeche Bank; it affected the spawning season of grouper and other resources (Arreguín-Sánchez 1992). Cyclic fluctuations in the abundance of the populations have also been mentioned as factors producing significant variations in the catches (Arreguín-Sánchez *et al.* 1993). Arreguín-Sánchez *et al.* assert that although there is no clear explanation for these cycles, the fall in CPUE could also be attributed to this phenomenon and not only to fishing pressure.

Contradictions among the estimates reported in the literature exist, especially in the case of grouper (Table 2.1). Additionally, diverse arguments regarding the reasons for the reduced catches have made it difficult to define changes in the policies to control fishing effort for this fishery. The SEMARNAP, however, asserts that the resource is at risk of overfishing and suggests a reduction of 40% in the harvest rate to allow the population to recover. Yet, it is not clear how this goal is to be achieved under current conditions of open access. Although introduction of a closed season for grouper has been proposed, strong opposition by the fishers has prevented its implementation. Currently, the main changes in regulation is reduction of the quota for the Cuban fleet

Table 2.1. Status of the main species caught in the Yucatán coast. The small-scale fleet includes 30% of the total grouper catches, 30% of octopus, and 100% of lobster.

Species	*Status*	*Yield in 1998 (tonnes)*	*Potential yield (tonnes)*	*Potential yield Estimate source*
Grouper	Overexploited	9000	22000	Chávez 1994
			30000	Arreguín-Sánchez *et al.* 1997.
			89500	Monroy 1998
Octopus	Overexploited	14000	7700-8300	Seijo *et al.* 1987
			7800	Solis 1994
Lobster	Stable	400	495	Ríos *et al.* 1998

Octopus

The octopus fishery started in Campeche State in the 1940s and in Yucatán in 1975. Currently, the three states in the Yucatán Peninsula (Campeche, Yucatán and Quintana Roo) contribute up to 85% of the national catch of octopus. The main species caught are *Octopus maya* (an endemic species) and *Octopus vulgaris*. The small-scale fleet targets mainly the former, while both species are caught by the industrial fleet in deeper waters (see Solis 1987).

In Yucatán, the catches increased from 6000 to 12000 tonnes at the end of the 1980's and have remained stable around 12,000 tonnes during the last decade. However, in 1996, they reached 25,000 tonnes (Figure 2.4). It has been suggested that this increase was due to the opening of the Japanese and Spanish markets, which almost doubled the octopus' price. This situation attracted more fishers to this fishery, thus an increase in the fishing effort has also been observed (Informe de Gobierno 1999; Castro *et al.* unpublished doc.)

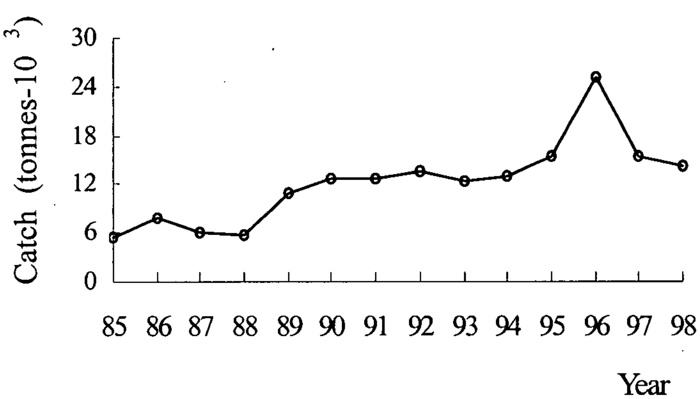

Figure 2.4. Trend of octopus catches in the Yucatán coast from 1985 to 1998.

Although octopus migration patterns have not been studied in depth, gradual concentration of adults close to the coastal area during the reproductive process have been reported (Solis 1987). Given these conditions and the short life cycle of octopus (1-2 years), the contribution of one cohort to the next is critical. Thus, high fishing intensity in one year may drastically affect the yield in the following year (Solis 1997). Furthermore, it is important for fishers not just to maximize the catch per season, but also to allow the population to be sustainable in the long term. Environmental factors also seem to affect catches. A trend has been observed in which increase in the landings coincides with the hurricanes in the previous year. According to the official records, the maximum catches obtained by the small-scale fleet are in September, whereas the industrial fleet peaks in November.

Arreguín-Sánchez (1992) reports trophic interactions between octopus and grouper. Arreguín-Sánchez and Zambrano (1995) developed a model to analyze the interactions of these species that suggest a decrease in octopus abundance when grouper biomass increases. In addition, fishing interactions between them are reflected in the fishers switching between alternative target species, which seems to be standard tactic observed in most small-scale fisheries (Panayatou 1982; McGoodwin 1990).

Stock assessment procedures have generated estimates of maximum annual yield of approximately 14,000 tonnes of octopus for the 1990's, which is almost half of the 25,000 tonnes caught in 1996. This underestimate, considering the current level of catch (Table 2.1), has been attributed by SEMARNAP to an overestimate of natural mortality and recruitment, associated with a miscalculation of the fleet's efficiency. Despite the catch increase in 1996, it has been suggested that the resources may be at risk of being overfished. A reduction in the catches of 2000 tonnes between 1996 and 1999 (Yucatán internal reports, 1999) was the basis in 1999 for SEMARNAP to suggest regulation of the fishing effort for this fishery.

Lobster

Panulirus argus is a gregarious species that moves to deep waters for reproduction. Juveniles are mainly in shallow waters in reef or rocky areas that provide refuge. They usually feed at night to reduce predation. Among their predators, octopus, grouper, and sharks have been reported as the most common (Briones *et al.* 1997). As small-scale boats operate in shallow waters, they target mainly juveniles and young adults. Some fishers operate in the Alacranes Kay reef using small boats to fish and mother ships to store the catch as well as for transportation of the boats to the keys and for taking the catch to shore (Ríos *et al.* 1998).

Of the total catch of the Yucatán Peninsula, 35 % of the catch is from the Yucatán State. In this state, the fishery started in the 1970s on the east coast (San Felipe and Rio Lagartos). By the 1980's, seven of the 15 ports joined the fishery. The main market is the USA, and only the tails are exported.

Lobster catches have been relatively stable in the last decade in Yucatán. They have averaged 350 tonnes but increased more than 100 tonnes between 1990 and 1994, and decreased again in 1998 (Figure 2.5, Table 2.1). One of the reasons for the relative stability of the population seems to be that the hookah method prevents fishers from reaching the fraction of the population that inhabits deeper waters (Seijo *et al.* 1991; Seijo *et al.* 1994). Another factor may be the lack of knowledge about the migration patterns and spatial distribution of the resource, which could limit the efficiency of the divers in Yucatán. In contrast, in Quintana Roo, México and Cuba, fishers take advantage of the lobster' migrations, increasing their catches by using nets to block the run (Cruz *et al.* 1990; Seijo *et al.* 1991).

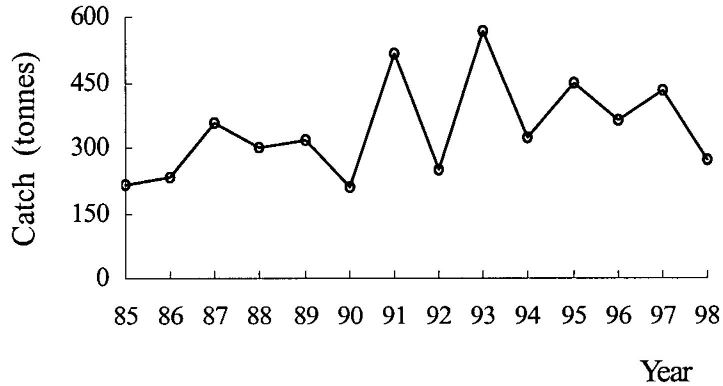

Figure 2.5. Trend of spiny lobster catches in the Yucatán coast from 1985 to 1998.

Given its high commercial value, there is always an incentive for fishers to enter the lobster fishery. Although the level of the catches has been relatively stable, differences in the volume obtained per area in the Yucatán coast reflect different levels of development or use of this resource. Ríos and Zetina (in press) suggest that fishing effort should not be allowed to increase in the North and East coast, but limited entry in the West coast could still be considered. However, proper enforcement and control of fishing effort on the whole coast is needed, because although the average lobster catch per fisher is not large, its high price makes this fishery profitable and attractive for newcomers.

2.2. Management and regulations

Legal access to fishing is through the purchase of a license or a concession. A license can be used for two years in practically any fishing area in the state; a concession lasts from five to 20 years and is restricted to an area specified by the government (see González and Gaita 1994). Lobster is the only species that can be caught through concessions, which have been given mainly to co-operatives. Other management tactics include control on the number of boats, type of gear, and the imposition of minimum legal sizes for several species. Closed seasons operate only for lobster and octopus. The fishing season for lobster lasts eight months (July to February) and four and a half months for octopus (middle of August to December). The Mexican fleet has unrestricted access to grouper and other demersal species during the year.

Some protected areas have been implemented in Yucatán. These include mainly terrestrial areas or some nursery areas (estuaries) along the Yucatán coast. However, particularly for the estuaries, limited enforcement reduces effectiveness in the protection of marine resources.

Although regulations are well defined in the region, they are not strictly enforced despite the recent transfer of enforcement to a special unit within SEMARNAP. Inconsistency between the goals of improving close inspection of fishers' catches along the coast and reduction of personnel to undertake this activity have resulted in poor records of the fleet operating in the area. High mobility of the fishers among landing ports also contributed to the difficulty of monitoring catches and evaluating the spatial distribution of the fleet. Some communities are relatively more stable than others though

It should be noted that there are limits to the ability to restrict fishing effort based exclusively on control of the number of boats or fishing licenses. Consequently, knowledge of the factors that influence the variation of the individual catch rates and the fishers' strategies for operating in different areas is important. Unfortunately, little attention to these issues has been given in the region previously.

2.3. Socio-economic sectors and marketing in Yucatán fisheries

The socio-economic agents involved in the Yucatán fisheries are the private sector and the social sector. The former owns most of the processing centres and the industrial fleet as well as part of the small-scale boats. The social sector concentrates mainly on fishing and owns primarily small-scale boats. Fishers from this sector have limited infrastructure to process and store their catches, which they sell mainly to the private sector. They tend to organize in co-operatives or other types of fishers' groups (for example rural organizations) to obtain credit for purchasing their boats and equipment. There are some fishers who do not belong to any organization ('free fishers'). They can be employed by the private sector or can work by themselves and then sell their production to any organization (see Salas and Torres 1997; Ríos *et al.* 1998).

The private sector contributes to about 83% of the state production and 75% of the landed value in the region. The co-operatives comprise 22% of the total landed value of the catches, coming mainly from lobster, for which many hold exclusive concessions (Salas and Torres 1997).

In Yucatán, as in many other areas, fishers are economically dependent on a few fish processors. From the 1940s to the middle of the 1980s, the government was the only financial backer of co-operatives and other fishing organizations. However, since subsidies have decreased, industrial companies have taken over the government's role as financial providers. Under such conditions, fishers have to sell their catches to those companies (Blondin *et al.* 1981). Fishers have limited market information, and as they do not have the means to process, transport and distribute their products, they depend highly on the middlemen. Furthermore, they have limited control on the price they receive, and the middlemen may pay whatever they choose (Blondin *et al.* 1981; Paré and Fraga 1994).

The three co-operatives of fishers analyzed in this study sell their products to the same buyer, thus prices are expected to be similar in the three ports. However, Dzilam Bravo and San Felipe co-operatives keep a small proportion of the landed value from each trip to cover the administrative costs and for the benefit of the fishing community. This pattern is not observed in Sisal, which results in the 'landed prices' being slightly different in the three ports. The co-operative that demands a greater share of the catch from the fishers is the one in San Felipe.

Figure 2.6 shows the landed prices of the main species during 1992 and 1993 in each port. Monthly differences are more pronounced for octopus and demersal fishes, especially in Sisal. In Dzilam Bravo the grouper price increased slightly compared with the other ports between March and June. The lobster price is defined always in USD at the beginning of the fishing season and remains constant until the end. For example, prices in January and February during 1992 correspond to those of the previous season, prices increased for the following season in July and remained constant until February of the next year. However, the price of octopus or demersal fishes can change during the year. Every co-operative has special arrangements with the buyer, and the prices can vary from one port to another occasionally. The portion allocated to the co-operative for administrative purposes varies between ports as well.

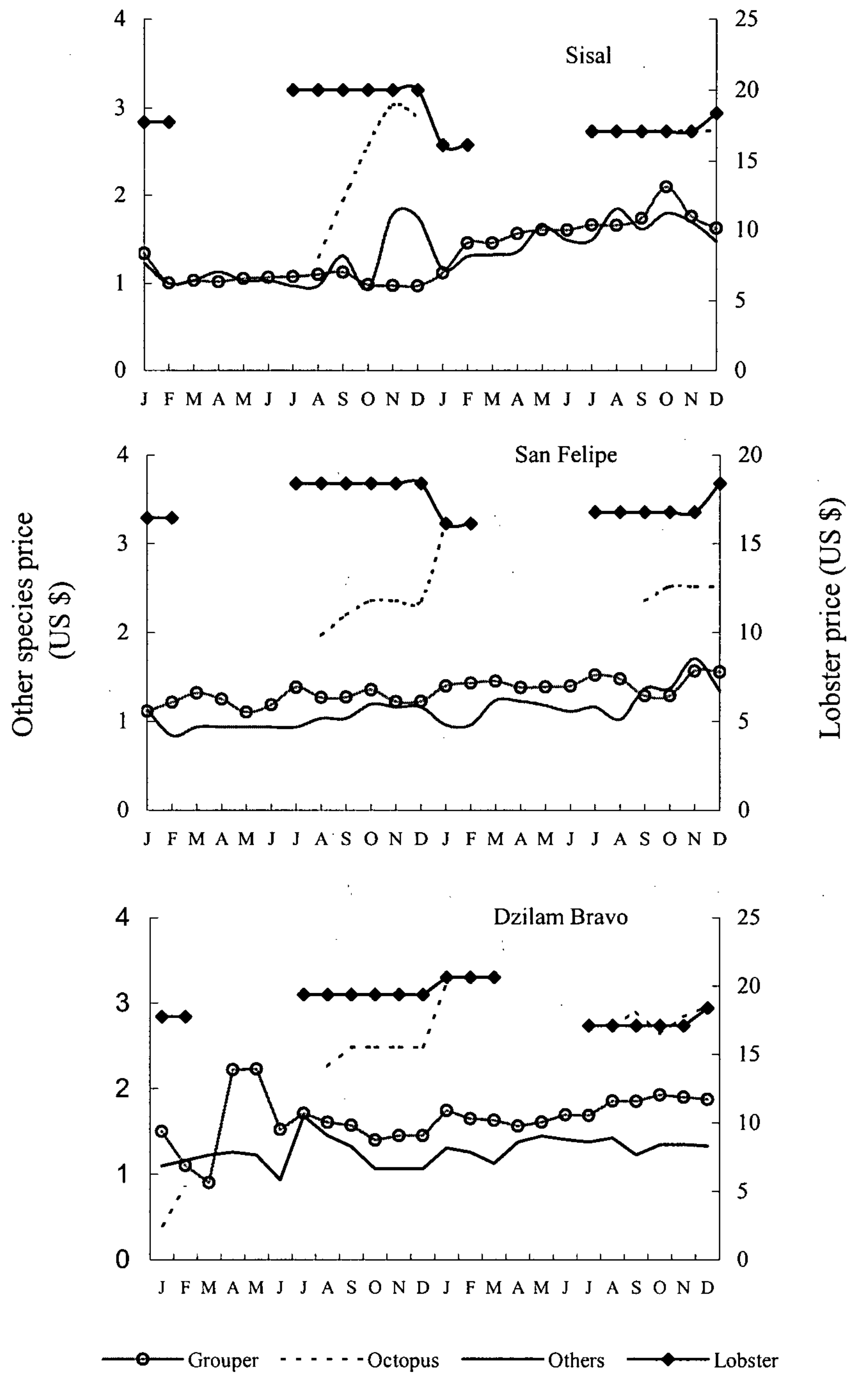

Figure 2.6. Monthly variation of prices for grouper, octopus, and lobster in Yucatán during 1992-1993. Notice the different scale for lobster. The prices were transformed to US dollar at an exchange rate of 3.1 pesos per dollar, which was the average rate in 1992-93.

The fishing communities

Small-scale fisheries in México comprise about 85% of the national fleet. In Yucatán these fisheries involve about 14,000 fishers, who organize themselves in different organizations, operate individually (free fishers), or work for the private sector. From the 15 ports along the coast, I selected three of them based on geographical location and other characteristics that make them attractive for comparison (Table 2.2). The selected ports are: Sisal on the west coast, Dzilam Bravo on the central coast, and San Felipe on the east coast. Fishers from these ports are organized in co-operatives, and their fishing activities are carried out generally in small boats (8-12 m).

Table 2.2. Boat attributes and characteristics of small-scale fishers in three ports of Yucatán in 1992.* Number of fishers officially registered in the co-operatives.

Characteristics	*Sisal*	*Dzilam Bravo*	*San Felipe*
Number of boats	17	70	100
Engine power (HP)	55-60	20-55	10-65
Boat length (meters)	8	7-10	7-8
Navigational aids (% of ownership)	Compass (100)	Loran (15)	Loran (15)
Number of fishers (*)	21	100	180
Social origin	Mainly farmers	Fishers and farmers	Mainly fishers
Experience (years fishing)	2-8	2-35	3-18
Age (years)	21-45	15-50	21-56

When the henequen production (American agave) dropped drastically at the beginning of the 1970's in the Yucatán state, farmers were encouraged through government programs to switch to fishing as an economic alternative and move to coastal areas. Some of the people assisted by the government joined existing co-operatives or organized other type of groups and migrated to different ports such as Sisal, Chuburna, Dzilam Bravo, and Progreso (Fraga 1992). Two types of fisher among these people have been identified by Fraga (1996): those that have settled permanently in the port and concentrate mainly on fishing ('residentes') and those that still maintain links with their original rural community ('pendulares'). The second group has not been totally integrated into co-operatives or other types of organizations and are recruited mainly as helpers, or concentrate at irregular intervals on collecting mussels close to mangrove areas.

An important characteristic of the people in the Yucatán coast is the seasonal and strategic use of all available resources. For example, some people combine fishing with other activities such as salt mining, tourism, and to a minor degree, agriculture (Figure 2.7). Tourism involves guiding people to the estuaries to watch birds or to hunt duck in areas such as Celestun and Sisal. Agriculture is a secondary activity in the coastal area. Paré and Fraga (1994) define this behavior as an adaptation process associated with uncertainty about environmental conditions, resource availability, physical characteristics of the region and the social structure of the communities. Blondin *et al.* (1981) also stress the importance of climatic conditions in the definition of cycles in the fishing activities of fishers in Yucatán. They report September and October as the most profitable fishing months of the year, mainly because of lobster. They also mention the 'Nortes' (Windy season) as a constraint for fishing activities.

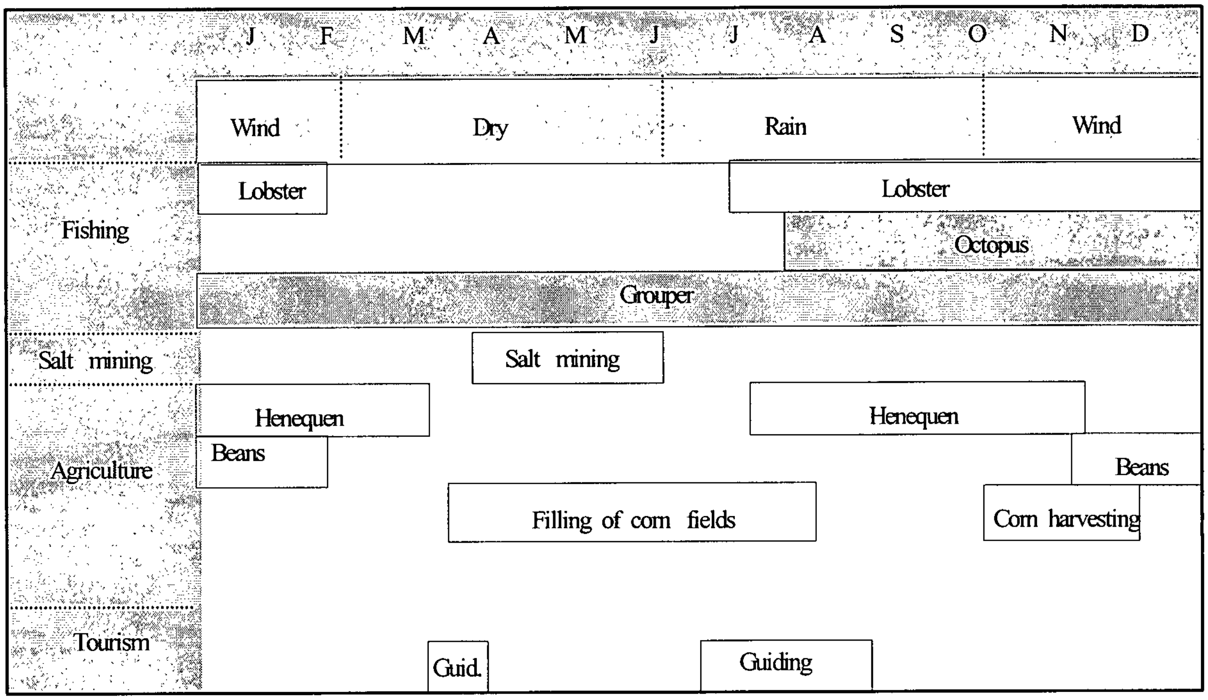

Figure 2.7. Seasonal use of the resources in Yucatán and typical division of climatic seasons of tropical areas and activities undertaken by people in the coastal area across the year. Modified from Paré and Fraga (1994).

In my study, I attempt to capture the flexibility of fishers given the characteristics of the resources they exploit and the uncertain nature of the fishing activity. Understanding the seasonal use of the resources in coastal areas is relevant when analyzing small-scale fisheries.

Sisal

Sisal is an administrative section smaller than a municipality. About 70% of the houses are mainly used during the summer for tourists coming from the cities. The permanent residents own rustic dwellings with limited water supply and sewage facilities. The urban infrastructure has not been well planned, therefore the area is not completely developed (GEY 1988). The fishers from the co-operative do not have any monetary commitment to the community, like in San Felipe. For example, in this last port, contributions from the co-operative go to improve parks or common areas where people gather. The level of education is very low among the inhabitants of Sisal; the members of the co-operative studied have at most no more than three years of elementary education.

Approximately 44% of the population in Sisal emigrated from rural areas, especially during the program promoted by the government called 'marcha al mar' (walking to the sea) looking for employment alternatives. While salt mining and fishing are the main activities in this port, harvesting crops is seasonal and generally includes people from the same port and surrounding communities (Figure 2.7). Guiding duck hunting is an occasional activity for people in the community during the summer (Fraga 1992; Delfin-Quezada, 1996).

Two co-operatives operate in this port in addition to other organizations that belong to the social sector. Only one co-op was selected for the study (Coxcaiba). In this co-operative most of the boats used are the same length and have similar engine power, as they were obtained through government programs. As in many other ports, members of the crew are not paid a wage, but instead receive a share of the catch. The sharing system is as follows: the boat owner gets half of the revenues, and the other members receive the other half in equal shares. Then the captain is responsible for the operation's costs, pay for his loan (if it exists), and maintenance of the boat. The number of fishers in each trip varies from three to four (Medina 1988).

Dzilam Bravo

This port has most of the basic services. Most of the inhabitants have completed an elementary education. Although official records indicate more emigration than immigration to this port during the 1980s, Fraga (1992) asserts that only a few immigrants have been able to integrate into the community. Immigrants are from rural areas (55%), other states (26%), other areas in the region (14%), and from metropolitan areas 5%. Fishers from some rural organizations that also fish in the area return to their community (Dzilam Gonzalez) every day after fishing. Fishers from the single co-operative operating in the port, however, do not include a high proportion of migrants; on the contrary, most of the fishers have a long fishing tradition, ranging from 2 to 35 years. These fishers register most of the landings from the social sector in that port.

Fishing and tourism are the main economic activities. Salt mining is an alternative activity from April to June for some people (Blondin *et al.* 1981; Fraga 1992). In the early 1980's coconut' plantations ('copra de coco') were also important in the economy of the area, in which oil was extracted for soap production (Blondin *et al.* 1981). However, a plague affected most of the plantations at the end of that decade and eliminated this economic alternative. In Dzilam Bravo, one area was established as a Biosphere Reserve in 1989 ('Las bocas de Dzilam') because of its high species' diversity and its importance as breeding area for demersal fishes and shrimp. According to the regulations, this type of reserve involves participation of the people living in the region for its conservation and monitoring. Economic activities are allowed under the supervision of the SEMARNAP.

As in Sisal, Dzilam Bravo fishers also have a share system in their catch after the deduction of travel costs, although the number of fishers per boats varies (2-3). The landed prices are defined by the co-operative according to the price fixed by the middleman, and a percentage that is used to cover the co-operative's administrative expenses. Among the main expenses are building improvement, truck repairs, and ice production for preservation of the catches in small storage rooms.

San Felipe

At the beginning of the 1960's, access to this port was possible only by boat. In the early 1980's, the government implemented programs to improve the infrastructure in the area, and attracted more fishers (Murphy and Magaña 1983). The beauty of this port, since it is near one of two protected areas on the Yucatán coast (Bocas de Dzilam and Rio Lagartos), has also attracted tourists. Fishers occasionally take tourists through the estuary, an activity that has become more common in the last five years (M. Marfil per. comm.). Additionally, since 1990 the single fishing co-operative in this port has made important contributions towards improving the infrastructure in the community. The maximum level of education of the people in the community is elementary, although a few fishers have gained high school education elsewhere.

The geographical location of San Felipe gives an advantage to the fishers in the area, owing to the existence of sand banks that protect the shallow area where small-scale fishers usually operate. However, this condition also limits the expansion of their fishing activities to deeper waters. Since the beginning of the 1980's, plans have been made to dig a channel to allow access for bigger boats (Murphy and Magaña 1983), but they have not yet been implemented.

Fishers from this area have a longer tradition in fishing lobster than have those from the other ports (Fuentes *et al.* 1991). Some of them claim to concentrate exclusively on lobsters and consider themselves different from the rest of the fishers (Murphy and Magaña 1983). The share system in San Felipe varies slightly from the other ports, as the shares divided among the crew are usually divided unequally. The owner of the boat always receives half of the share and the rest is divided among the rest of the crew according to experience, hence beginners or newcomers can obtain less than those that have more experience or have lived longer in the community. The number of fishers per boat varies from two to three.

As an economic alternative, about 10% of the population in this port breed cattle in an adjacent community within the same municipality (Panaba). Even though some immigrants have moved to this port from other states, the percentage is lower than in Sisal (19%), and according to government reports (GEY 1988) the reasons for migrating are mainly to join relatives.

2.4. Remarks

In the last decade, the need to control fishing effort to reduce grouper and octopus mortality has been recognized. At the same time, further development of the lobster fishery has been promoted, despite the limited knowledge of the biological capacity of this stock and the fact that fishers tend to adapt their boats to target alternative species. Furthermore, if the fleet to catch lobster is allowed to increase, there is a possibility that these boats could exploit other species such as those that are already at risk from overfishing.

Despite the problems described earlier, an increase in the number of boats and fishers has been observed in the last 10 years (Figure 2.8). According to official reports, the number of boats in the 1990's has almost doubled the total fleet size (SEMARNAP 1998). As in other coastal regions of México, Yucatán has attracted people looking for alternative employment, especially those from rural areas. One of the consequences is that fishing organizations have increased approximately 300% in their membership during the same period (Salas and Torres 1997). At the same time, although the catch from the entire state has increased in the last two years, a reduction in the average return per fisher has been observed (see Cabrera 1997; Monroy 1998).

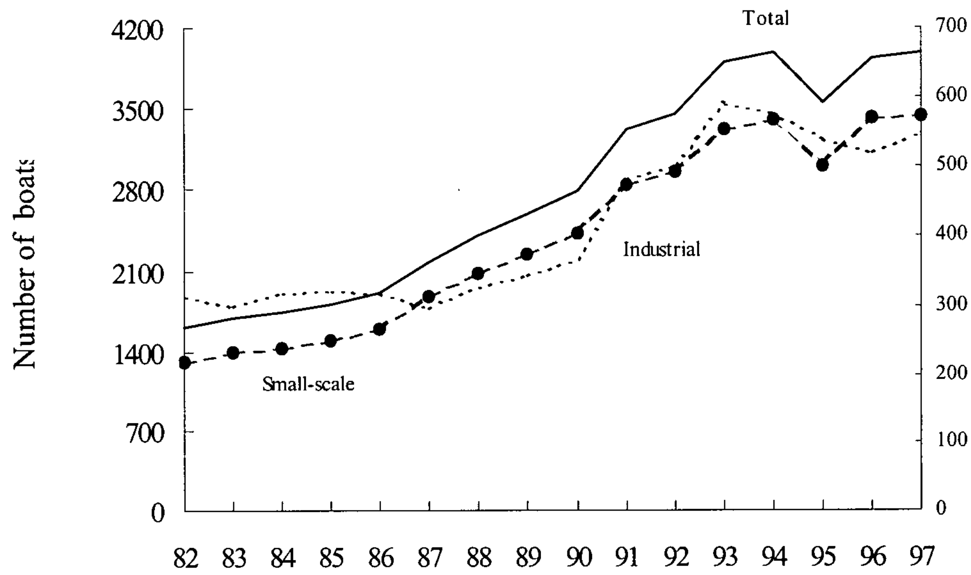

Figure 2.8 Trends of fishing effort in terms of number of boats in the Yucatán coast. Notice different scale for industrial fleet from the total and small-scale fleet.

Summary

Small-scale fisheries in Mexico comprise about 80% of the fleet and 40% of the national production. The increase in this fleet has occurred over a short time-period as the coastal area has become an attractive alternative location for displaced farmers from neighboring regions or elsewhere. Seasonal use of resources has been observed in the coastal area, where fishing is the main activity. Interactions among gear, fleets, species and even among fishers are part of the dynamics of these tropical fisheries. Limited spatial and temporal information has limited the analysis of these fisheries. This makes it more difficult to implement management regulations consistent with the changes taking place. As in other fisheries of this type, the multiple use of the resources in Yucatán and the mobility of the fishers make it even more difficult to evaluate and monitor fishing effort. This activity is based mainly on three resources (lobster, grouper and octopus), that are fished across a long coast with 15 landing ports. From these ports, I selected three that present common features and some differences that make them attractive for comparing fishing strategies; they target the same species, are subject to the same regulatory scheme, and have the same buyer. Under these conditions, fisheries managers have assumed fishers as homogeneous groups when analyzing and defining the regulations, regardless of the differences in the groups analyzed and noted through this chapter.

CHAPTER 3

Fishing tactics, strategies, and individual variation

3.1. Introduction

Homogeneity among fishers has been the initial assumption in many fisheries models, and this stereotype is still maintained among fisheries managers. However, natural and market variability leads to uncertainty, which fishers have to face by adapting their fishing strategies or by seeking new alternatives within the fishing activity or elsewhere. These conditions generate differences in the fishing practices among groups of fishers and even within groups. I recognize that other components can constrain fishers' activities, such as internal or local (community, co-operative) regulations and political factors. However these are not addressed in this study.

Fishing strategies have been defined and described in different ways, from the fishing methods employed (Davis 1984; Blondin *et al.* 1981; MacGoodwing 1990; Jennings and Polunin 1996), to the choice of locations, target species, and time spent in different fishing grounds (Smith and McKelvey 1986; Defeo *et al.* 1991; Begossi 1996; Ferraris and Samba 1991; Ferraris 1993; Gascuel *et al.* 1993). Béné (1996) defines strategies as a result of a combination of tactics that reflect the compromises fishers face between constraints and their aims. In some cases fishing tactics and fishing strategies have been referred to as equivalent (Cove 1973, Acheson 1981).

Even though the importance of understanding fishers' behavior for fisheries management has been repeatedly referred to in the literature (Pringle 1985; Charles 1995), few analyses exploring fishers' strategies have actually been conducted in an integrated way, especially in the context of small-scale fisheries (Pelletier and Ferraris 2000). In these fisheries, the fleet exploits multiple species either simultaneously or sequentially in the same or different areas. These conditions make it more difficult to identify the components of fishing effort and its changes.

According to Pelletier and Ferraris (2000) there are two levels at which fishing tactics and strategies can be characterized namely the fishing units (vessels and crew) and the fishing operations. The former considers long-term assessment and the latter short-term, which can vary within season or within day. In this study I focused on the fishing operations of fishers in Yucatán within a season.

The need of understand how individuals reconcile conflicting demands in order to achieve their goals, has promoted the study of fishers' behavior in fisheries science. In this context, fishers' strategies in the short-term may be motivated by status, and the degree of difference can vary across and within groups. However, these aspects are seldom considered when fisheries are analyzed.

In this chapter, I analyze the seasonal fishing operations of small-scale fishers in order to identify their fishing strategies. The analysis was based on catch and effort data recorded on a daily basis in three ports of Yucatán, México. Fishers from these ports present some common features as well as exhibit differences that make them ideal for comparison (see Chapter 2). All of the fishers are organized in co-operatives, they have a common buyer, and the regulatory schemes are the same for the whole region. Given these conditions, it could be assumed that 'market constraints' and the regulatory regime influence them all in the same way. However, different contexts faced by fishers from each port may also influence the way they operate. Some of them even perceive themselves differently. For instance, some fishers in San Felipe claim to specialize in lobster, as they consider themselves good divers, better than the 'average fisher'. Furthermore, given the features shared by fishers in the three ports, the following questions arise in testing for homogeneity among fishers:

- is it possible to expect fishing patterns to be similar in all the analyzed ports?, and if not
- how do fishing patterns differ among ports?

3.2. Sources of information and analysis of data

As mentioned in Chapter 2, although many species are captured on the Yucatán coast, grouper, lobster, and octopus comprise 60% of the landings. Therefore, the analysis focuses on these species, while other species are pooled and referred to throughout the text as others.

Daily catch data recorded in logbooks during 1992 and 1993 by species and fisher were provided by the co-operatives in each of the ports studied. These logbooks do not form part of a compulsory provision established by the government, but are part of the bookkeeping that fishers use for internal administrative purposes. The books include the same information that fishers receive on their 'payment slip' when landing their catches, which confers reliability of the data. Most of the fishers take some fish home at the end of their journeys (1-2 kg), and these data are not included in the records. Additionally, landing prices on monthly basis for each of the species analyzed were acquired both from the bookkeeping records of the co-operatives and from the main fish buyer in the region. Slight differences between the prices paid by the buyer to the co-operative and those the co-operative pays to the fisher are due to the contributions fishers have to make in order to cover administrative expenses for the organization (see Chapter 2). Information related to wind speed and temperature trends during the same period in the study area (used in some analysis in this section) was provided by The Meteorological Center in Yucatán. I also had access to secondary sources of information both about the technical characteristics of the boats and information about the fishers, which was obtained from the same co-operatives, internal reports from the Ministry of Fisheries in Yucatán, and the research centers CINVESTAV and CRIP Yucalpeten.

Logbook data included records from 16,478 trips in 1992 and 16,237 in 1993 undertaken by 280 fishers distributed in the three ports. From this total, 60% of the fishers were from San Felipe, 25% from Dzilam Bravo, and the remaining 15 % from Sisal. In 1993 only six months of catch data from the Sisal logbooks were available (January-June) because administrative changes in the co-operative left the other semester missing. This constrained comparisons for Sisal across years.

Fishing effort (*f*) was defined as the number of days fishing. It was not possible to distinguish fishing effort applied to each species caught in every trip, since in many cases, more than one species was caught. In Sisal and San Felipe, fishing trips are on daily basis; thus a fishing day can be considered equivalent to one trip. However, in Dzilam Bravo, 18% of the boats are larger (12 m length) than average (8-10 m length). These boats have a cooling system that allows fishers to preserve the product during longer journeys and they made an average of six-day trips. The journey comprises two days traveling and searching for fishing grounds and the rest fishing. Therefore, four days were considered as the effective number of fishing days per trip for this type of boat. For comparison purposes among and within ports, I made this assumption for transformation of weekly trips in Dzilam Bravo to a daily basis. Therefore, the total number of trips after the transformation from all the three ports was 20,653 in 1992 and 23,737 in 1993.

A catch profile per species was obtained for every port. This estimate was based on the composition of catch and landed value through the year. I estimated the landed value (LV_{itkz}) as the product of catch of species *i* at time *t*, from fisher k, in the port z (C_{itkz}), times the monthly average landed price of species *i* at time *t* in port z (P_{itz}). Catch was defined in kilograms and price and landed value in USA dollars. For transformations of currency I used an exchange rate of 3.1pesos/1US dollar, the average rate for the years analyzed. Time was defined by months, hence.

$$LV_{itkz} = C_{itkz} * P_{itz} \tag{3.1}$$

I also estimated an index of individual fishing efficiency (FE_{tkz}) according to the modified formulation proposed by Abrahams and Healey (1990), defined by them as the competitive ability index:

$$FE_{tkz} = \frac{LV_{itkz}}{f_{ktz}} \qquad (3.2)$$

where: k, z and t are the same as referred in equation (3.1), and f corresponds to daily trips summarized on a monthly basis.

As mentioned in Chapter 1, the concept of fishing efficiency has been defined in different ways. In this particular study, given the significant differences in price of lobster related to other species, I selected landed value instead of catch to estimate fishing efficiency. For example, catching approximately 5 kg of lobster could be equivalent to fishing 40 kg of octopus. In the next chapter I evaluate the fishing performance in terms of catch and landed value as well.

To evaluate the differences in fishing efficiency between fishers among and within ports, I applied the Kruskal-Wallis non-parametric statistical test, because the data did not follow a normal distribution (Siegel and Castellan 1988; Norusis 1997). I used the same test to compare patterns between years.

3.3. Results

Results are presented in two sections, first I show the seasonal patterns observed in each port summarizing information from all fishers; secondly, in order to identify the fishers' strategies, I present the results derived from analyses of the information at the individual level.

3.3.1. Seasonal patterns

Total catch per year and number of trips was higher in San Felipe than in the other two ports. In this port, catches remained stable from one year to the next. Contrary to this pattern, in Dzilam Bravo maximum catch was reduced by 10% after an increase in the fishing effort in 1993. Minimum catch per month was similar in San Felipe and Dzilam Bravo and the lowest corresponded to Sisal (Table 3.1).

Table 3.1. Total annual catches (tonnes) and daily trips in the three ports during 1992 and 1993. Sisal includes data from six months only.

	1992			*1993*		
	Sisal	*San Felipe*	*Dzilam Bravo*	*Sisal*	*San Felipe*	*Dzilam Bravo*
Catch	67.9	474.4	388.5	27.4	570.9	340.7
Max	8.3	81.9	60.6		80.8	44.9
Min	4.9	12.4	15.3		14.6	12.5
Trips	1973.0	10345.0	8335	1161.0	10906.0	11670

Fisheries scientists have stated that fishing effort tends to be concentrated where the resource is more abundant (Walters and Bonfil 1999; Defeo *et al.* 1991). This appears to be the case in Yucatán. For instance, given that fishers can fish species other than lobster and octopus throughout the whole year, the number of trips increased when the fishing season was open for these species (Figure 3.1). Thus, overall, a higher number of trips were observed in July and August in both years at all the ports.

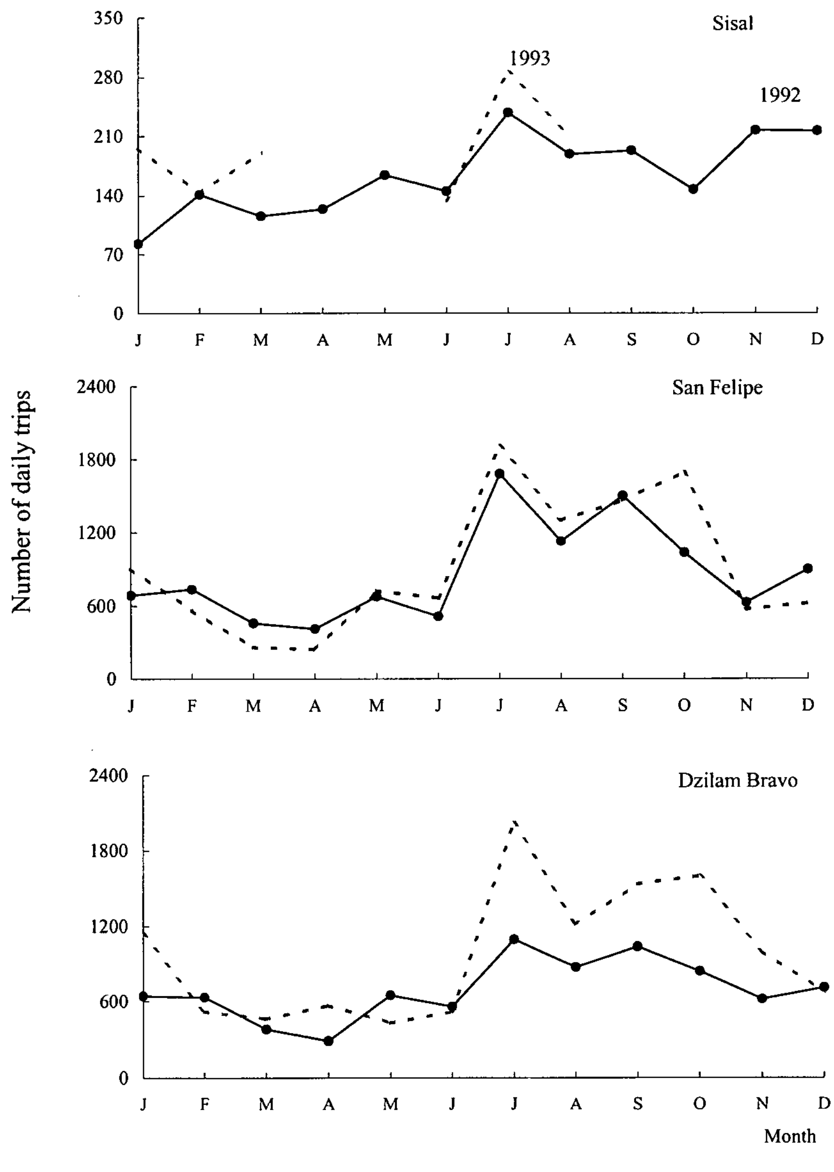

Figure 3.1 Monthly distribution of fishing effort (daily trips) in the three ports during 1992 and 1993.

Although, the trends of fishing effort were similar among the ports, significant differences were observed in the number of trips undertaken by fishers in each port (Table 3.2, Kruskall-Wallis, N=20000). In Dzilam Bravo, for example a 40% increase in the number of trips from 1992 to 1993 resulted in reduction of catches (~10%). In San Felipe by contrast, the total number of trips varied little from one year to the next, as did the total catch. Limited information in Sisal for 1993 constrained the comparison for the second semester of 1993; nonetheless, increase in the number of trips in the first semester was clear compared with the same month in 1992.

Table 3.2. Comparison of monthly fishing effort in three ports of Yucatán. Chi-square values and df at P=0.001(**) and P=0.005(*).

Variation	*Sisal*		*San Felipe*		*Dzilam Bravo*	
	1992	1993	1992	1993	1992	1993
Across the year (df=11)						
Fishing days	**78.07	*47.70	**378.08	**447.70	**100.18	**164.09
Among fishers						
Fishing days	*30.96	18.38	312.97	**382.33	**448.69	**479.68
df	16	14	150	148	99	118

Monthly variation in the composition of the total landed value (Figure 3.2) followed a similar trend to the fishing effort. That is less clear in the case of the catch composition given large differences in price of the species, especially lobster (see Appendix I.1). For instance, at the opening of the lobster season fishers expect high concentrations of the crustacean while weather conditions also favor this fishery. At this time, it is common for fishers to search for lobster at the artificial habitats in addition to their usual search. A second peak in fishing effort noted during September-October in San Felipe and Dzilam Bravo, and November-December in Sisal, coincides with high catches of octopus during its recruitment period (Solis 1994).

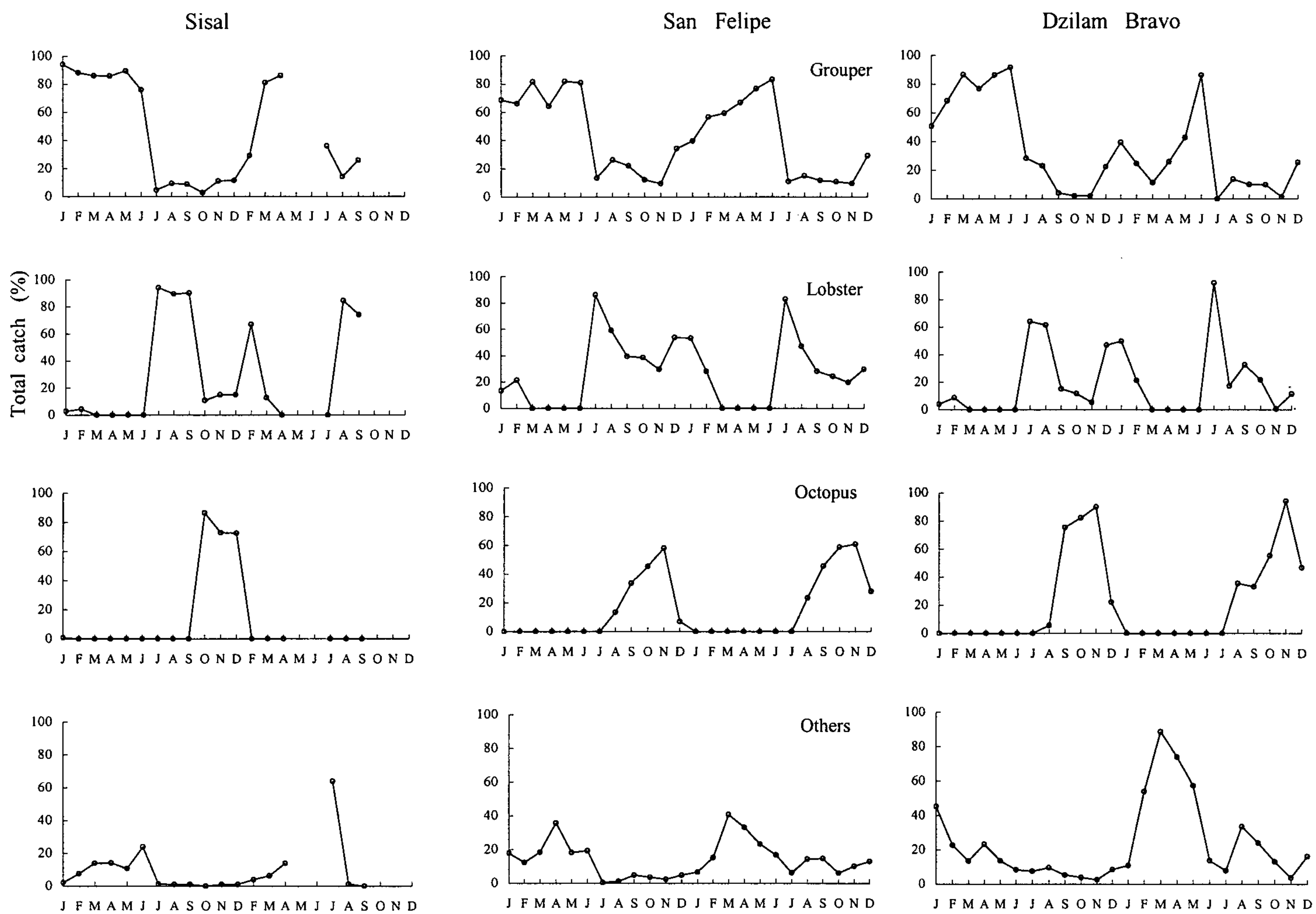

Figure 3.2. Catch composition in terms of landed value in three ports of the Yucatán coast in 1992 and 1993

During July-September, fishing lobster provided most of the revenues, which oscillated from 60% (San Felipe and Dzilam Bravo) to 90% (Sisal). A shift to octopus during October to December was observed with contribution of 80% of the revenues in Sisal and Dzilam Bravo and 60% in San Felipe. Despite the overlap in the fishing season for both species from August to December, fishers appear to concentrate more on octopus than lobster after October, regardless of the profitability of the latter. During that time, environmental conditions are less favorable for fishing lobster so that searching for the crustacean requires more time. Thus, it would be easier for the fishers to obtain large catches of octopus without much uncertainty; this could compensate, under adverse conditions, for the loss of high revenues from lobster.

Although the season for octopus starts in August in 1992, fishers from Sisal concentrated mainly on lobster from July to August, and fished for octopus until October. The available information suggests that fishers take advantage of lobster concentrations at the beginning of the season and shift to octopus when fishing lobster is more risky during windy periods ('nortes').

3.3.2. Individual fisher variation

At first sight, composition of the total catch and landed value per fisher appear to be similar for all ports and the comparative analysis among ports indicated no significant differences with respect to lobster and octopus, but significant differences for grouper and others. This was not the case when mean catch by species and fisher was considered instead of the total, and significant differences were observed for all species in the three ports (Table 3.3 Kruskall-Wallis, N=18,000).

Table 3.3 Chi-square values for composition of catch by individual fisher in the three ports at P=0.01(**) and P =0.05(*).

Species	*1992*	*1993*
Total catch		
Grouper	**18.9	**248.6
Lobster	2.76	**472.5
Octopus	2.01	**104.2
Others	**23.31	**197.9
Mean catch		
Grouper	**48.88	**235.53
Lobster	**36.67	**24.88
Octopus	*16.99	**45.93
Others	**109.92	**32.04

Variation among fishers was confirmed by the frequency distribution of the catch, where a skewed distribution for all the species indicated differential efficiency of fishers, i.e. a minority of fishers obtained much higher catches than the majority. Example of the catch distributions of the main species caught by fishers in San Felipe is presented in Figure 3.3 as an example. This resulted in significant differences among fishers and across the years (Kruskall-Wallis test, see Appendix I.2).

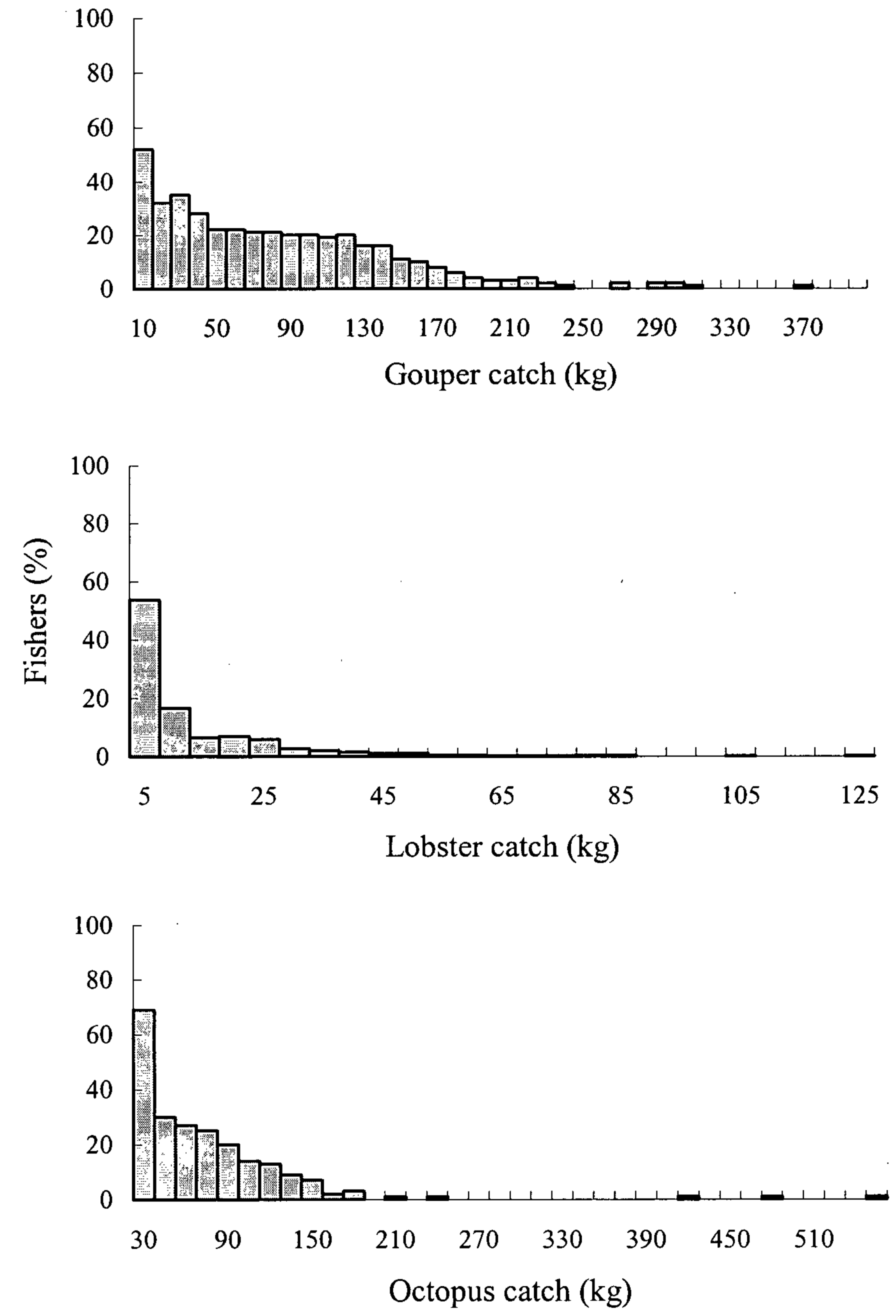

Figure 3.3. Frequency distribution of catch of main species in San Felipe during 1992.

3.3.3. Switching behavior of fishers

Monthly composition of the catch in terms of landed value indicates a clear switching behavior of fishers across the year between the main species. Daily catch data by species and fishers allowed me to observe the shift from one target species to another from month to month. For example, in Sisal, as mentioned earlier, none of the fishers fished octopus during August even though the season was open already. However, they shifted to octopus by October, when only a few fishers caught small amounts of lobster. In this port the shift from one species to another was done in clusters, i.e. most of the fishers shifting almost simultaneously. For instance, in November, by the first half of the month fishers were catching octopus exclusively, but by the third week the majority had shifted completely to lobster (Figure 3.4).

A shift in cluster, though less explicit, was also observed in Dzilam Bravo (see Appendix I.3), but not in San Felipe. In this port, fishers seem to operate in a more independent way and the shift was less evident from day to day (Appendix I.4). Some gaps in some months can be observed when nobody went fishing in the three ports. These gaps were associated with environmental conditions that limited the activity or by special events in town (celebrations, parties, etc.).

The data shown in Figure 3.4, also confirm the differential efficiency of fishers mentioned earlier. A wide range of variation in the catches can be observed, especially in San Felipe and Dzilam Bravo. In Sisal this occurs mainly for octopus and is less variable for the other species.

Changes in the mean catch of the different species across the year also indicate the switching behavior of small-scale fishers over the main species in Yucatán. During the closed season for octopus and lobster for instance, grouper and 'others' dominated the catches. In both years, average values ranged over 50-90 kg per trip in Sisal; 60-100 kg in San Felipe, and approximately 150 kg in Dzilam Bravo, where some fishers even achieved catches between 600 and 1200 kg per trip. Only a few fishers caught lobster in January and February (5 to 10 kg per trip). In March, despite the fact that the season was closed, some fishers in Dzilam Bravo reported occasional catches.

At the opening of the lobster season, grouper dropped in Sisal and San Felipe to 5 to 10 kg per trip, while average catch of lobster increased close to the 20 kg per trip. In Dzilam Bravo, on the other hand, some fishers still continued to fish grouper and others, maintaining high catches of these demersal fish even during lobster and octopus seasons.

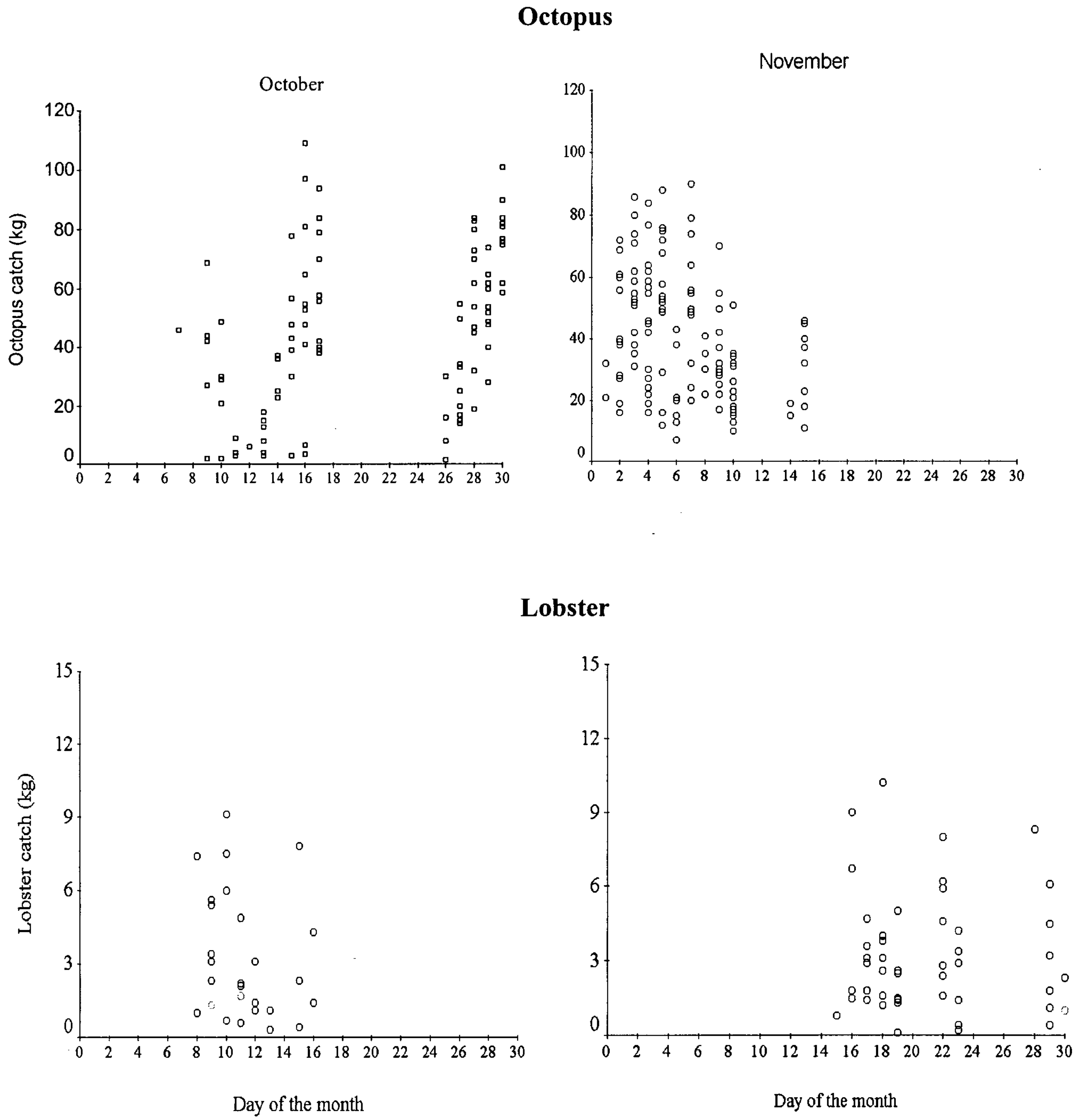

Figure 3.4. Daily catch per individual fisher in Sisal in two periods of 1992 as an example. Every dot represents an individual fisher. Notice that in November most of the fishers switched almost simultaneously from octopus to lobster. The range of variation in the catches also indicates differential fishing efficiency among fishers.

If fishers in Yucatán had no other constraints other than official regulations, such as the closed seasons (March-June for lobster and middle of December to July for octopus), and if they were trying to maximize their catches, it would be expected that they would target lobster (the most profitable species) during the entire fishing season. However, switching target species may also be a way of how fishers cope with a changing environment, given the availability of the resource and access. Another reason for which a particular species is selected could be due to limited ability to master a new fishing gear or method, because changing species also involves changing fishing methods and gear.

In San Felipe some fishers claim to be good divers concentrated entirely on lobster, which involves not only economic rewards, but also an individual recognition in the local community as being a skilful fisher. In the same line, Fraga (1992) asserts that migrant fishers coming from rural areas tend to select a fishery that does not require special skills. This has been confirmed by the local fishers, who mentioned in informal conversations that some fishers, especially those who migrated from rural areas, do not know how to dive, and some of them do not even know how to swim. Despite this, because the hookah system allows such novices to go underwater for extended periods of time, many of them might decide to go for lobster. However, there is always the risk of the 'hookah' hose breaking. Where weather conditions are unfavorable, many fishers do not dive. Other fishers, though, are more competitive to do so during the whole lobster season (July-December), because being 'a good lobster-man' implies 'being a good diver', which provides status in the community.

Fishing for both lobster and octopus is generally incompatible because of the different types of gear and limited space in the boat generally prevents fishers from carrying both gears. Also, given the trophic interactions between these animals, it is rare to find them together. However, octopus can be extracted from their refuges with a hook during the search for lobster. Catching lobster while fishing for octopus is less common. Demersal fishes are always available under the present regulations. Fishers can catch grouper by line fishing while the boat drifts catching octopus, or with a spear gun when diving (see Chapter 2).

3.3.4. Specialist or generalist fishers

Most of the fishers in the three ports land more than one species during the year, so in this respect, fishers are generalists in the sense defined in Chapter 1. However, the catch composition derived from the individual catch records could also suggest a fishers' preference for a particular species. This could be the case either because of the price of the species, the flexibility in the type of gear used, or both. In an attempt to test the claim of fishers from San Felipe that claim to be specialists for lobster, and to evaluate potential preferences of fishers for particular species, I estimated an index value (*IV*) for the main species caught in the region and analyzed the catch composition using this index as my reference. I calculated the ratio of each one of the species' monthly average price (*spp$*) with respect to lobster (*Lob$*), the species with the highest price.

$$IV = \frac{Spp\$}{Lob\$} \qquad (3.3)$$

Although economic assumptions are made here to estimate the index, preference for any of the species could also indicate preference for certain fishing gear, as different methods and gears are used in each case and different skills are required. Four categories resulted from estimating this index value, one for each species and one that I defined as a combination, which I estimated from the average price of all the species divided by the lobster price. This index will be equivalent to 1 for lobster as a reference point. It is important to notice that landed value is considered instead of net revenues, however, differences in the cost involve in targeting each species could modify this index. For example less gasoline is spend while fishing octopus than fishing lobster and this can affect the costs and consequently the net revenues and the value of this index. Hence changes in the index value could occur along the season as well and could be used as a reference to look at changes in target species. Limited information in cost per trip did not allow to undertake the analysis at this level, so the present results are considered as valid in general terms and alternative analysis can be undertaken provided more information in the future.

Results in Table 3.4 show that after lobster, combination of species provided a higher index value than that based on grouper or octopus alone. Grouper and others have similar values because the prices are similar. This pattern was consistent for both years although a slight increase in the index value in 1993 is a consequence of a slight increase in the landed prices for all species in that year (see Chapter 2). These results likely confirm the generalist nature of small-scale fishers. However, questions that arise are how are these combinations made up? and would fishers target one particular species if they were able to do so?.

Table 3.4. Index value for main species caught in Yucatán compared to lobster as price baseline in 1992 and 1993.

Species	*1992*			*1993*		
	Sisal	*San Felipe*	*Dzilam Bravo*	*Sisal*	*San Felipe*	*Dzilam Bravo*
Lobster	1	1	1	1	1	1
Grouper	0.05	0.07	0.09	0.10	0.09	0.10
Octopus	0.12	0.13	0.13	0.16	0.15	0.16
Others	0.06	0.06	0.06	0.09	0.07	0.07
Combination	0.24	0.27	0.27	0.34	0.31	0.32

The catch composition in terms of landed value was analyzed based on three possible combinations of the proportion of species landed in each trip. The categories were defined as follows:

Combination 1 (Comb1)= when grouper>=70% of landed value

Combination 2 (Comb2)= when lobster>=70% of landed value

Combination 3 (Comb3)= when octopus>=70% of landed value

From the composition of the catch, 70% of the landed value of the catch was selected as the minimum percentage that would help to identify preferences in each trip for a particular species during each year. That is if the landed value of fisher A comprised 70% of grouper and the rest of other species, it would be assigned to Combo 1 and so on.

In Sisal, during 1992, 10% of fishers targeted octopus as the main catch species. Additionally, 22% of them fell into category Comb3, which indicates fishers' preference for octopus. In 1992, in San in Felipe, about 14% of the fishers concentrated exclusively on one species, and only about 2% did in 1993. Surprisingly, fishers did not catch lobster exclusively in this port. Some fishers targeted octopus and other demersal fish. Only 4% of them caught lobster restrictively. However, Comb2 (mainly lobster) was higher in this port than in the other two (22%). In Dzilam Bravo, preference seems to be given to grouper by specialist fishers (10-20%); additional 15% of the fishers in this port fell in the category Comb1 (targeting mainly grouper).

Figure 3.5 shows the proportion of fishers that fell into each category. For instance, in 1992, fishers' preferences for octopus in Sisal, for lobster in San Felipe, and on grouper Dzilam Bravo were observed. This pattern however was not consistent in 1993 for Sisal and San Felipe. Only in Dzilam Bravo between 7 to 10% of the fishers targeted one species exclusively (namely grouper, lobster or octopus).

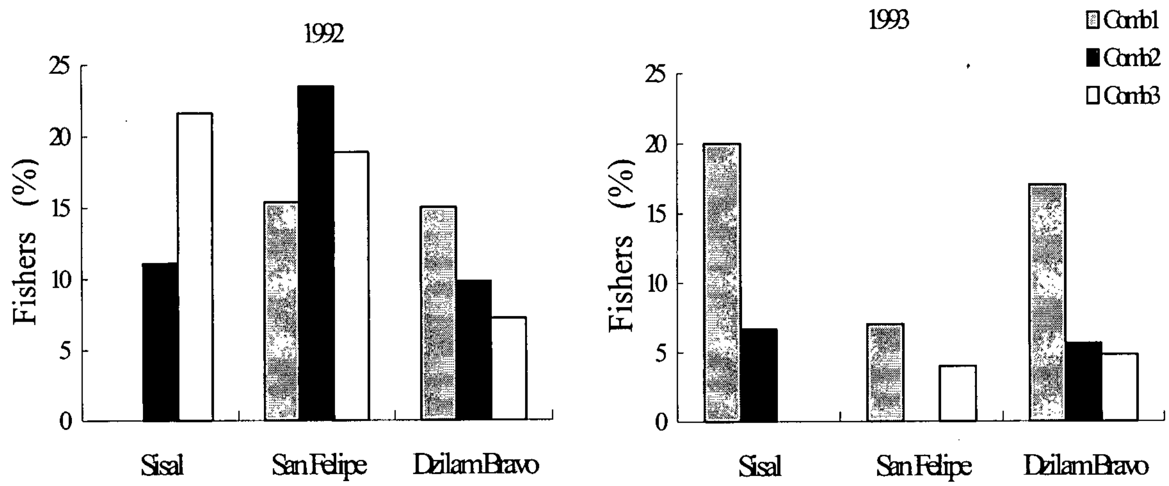

Figure 3.5 Preferences of fishers for target species. Comb1- grouper>70%, Comb2 - lobster>=70%, Comb3 - octopus> 70%.

It is important to bear in mind that information for Sisal from 1993 was incomplete and it does not include the octopus catch. Comparison among fishers for each category indicates significant differences in San Felipe and Dzilam Bravo, but not for Sisal (Cochran test Q: San Felipe Q= 12.6; Dzilam Bravo Q=29.6). Significant differences among ports were observed for these categories as well (Kruskal-Wallis, Chi-square: Grouper=111.9, lobster= 33.1, octopus =48.6).

From the fishers who targeted solely one species, 16% in San Felipe and 15% in Dzilam Bravo were temporary residents of the ports or did not belong to the co-operatives, but landed their catches in those ports occasionally. Consequently, they can were considered either opportunistic or part-time fishers, a common pattern observed in small-scale fisheries (Agüero 1992; Knudsen 1995). There was no information about other economic activities available to these people as alternative or complementary sources of income.

Specialization by area, gear, or species has been reported in several fisheries, mainly in temperate waters and in industrial ones. In small-scale fisheries like those analyzed in this study, specialization appears to be less common as fishers tend to adapt to maintain a range of options within the fishing activity and elsewhere (see Davis 1984; Silvestre and Pauly 1997). Smith and McKelvey (1986) describe these types of fishers as 'portfolio builders' who switch targets as the season progresses and opportunities arise. Under changing conditions fishers can trade off efficiency of specialized operation for flexibility. This flexibility may not exist when equipment, geographical conditions or skills restrict the range of options available. This could be the case of migrant farmers in Sisal, whose limited abilities as divers may orient them to fish octopus rather than lobster in part of the overlapping of the seasons, regardless of the higher profitability of lobster.

Relationship between species targeted and age of fishers

The range of fishers' ages was almost similar in all three ports, with no apparent direct relationship between fisher age and mean catch for any of the species. However, some fishers claim that fishing demersal species like grouper are preferred by old fishers, while diving for lobster is more common among young fishers because it requires more effort and skill. Fishers in the three ports ranged from 15 to 63 years old, and at first sight no apparent differences by age and the total catch of the species they caught were evident. However, a significant and negative correlation was observed between fishers' age and mean catch of lobster in San Felipe and Dzilam Bravo, but not in Sisal (Table 3.5). In Dzilam Bravo, on the other hand, grouper also showed a significant but weak correlation with fishers' age, which was also noted in the case of octopus catches in Sisal.

Table 3.5 Correlation coefficients for mean catch of different species and age of fishers (Sperman's: P =0.01(**); P= 0.05 (*).

Species	*Sisal*	*San Felipe*	*Dzilam Bravo*
Grouper	0.030	0.060	*0.060
Lobster	0.004	**-.0150	**-0.100
Octopus	*0.050	0.040	0.040
Others	-0.02	0.090	0.020

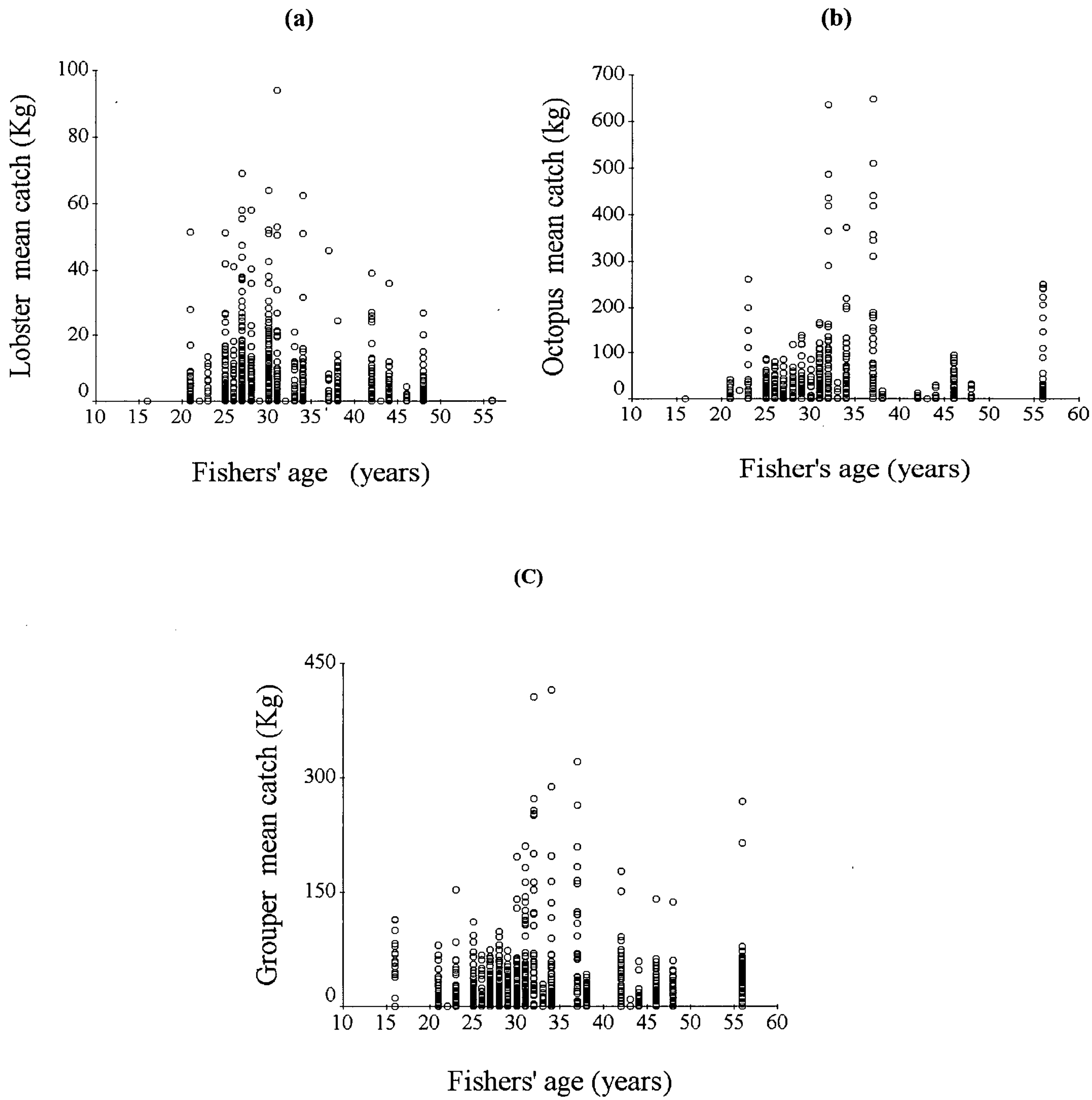

Figure 3. 6. Relationship between mean catch of fishers for: a) lobster, b) octopus, and c) grouper caught in San Felipe in 1992.

Although the correlation coefficient for lobster is weak, Figure 3.6 shows that fishers younger than 20 or older than 50 years old did not catch lobster. This is not the case for the other species, where from an early age, children begin to help their parents or relatives and thereby learning how to fish. The risk associated with fishing lobster, is acknowledged by the fishers as some of them have suffered decompression sickness and even died from careless use of the equipment (see Chapter 2). It is uncommon for children to dive for lobster, but they can participate in this fishery at early ages, mainly as helpers to look after the compressor and hose operation for the safety and security of the diver. Older fishers also appear to be more comfortable fishing other species, although some of them still can target lobster at the beginning of the season searching the artificial habitats or areas close to their homeport. Higher mean catch of lobster was obtained by fishers ranging between the age of 25 and 35.

3.3.5. Cooperation teams

Exploration of the daily catch data in the logbooks allowed me to identify a unique fishing strategy used in Dzilam Bravo. Some fishers in this port operated cooperatively, usually consisting of two boats per team. I term this as cooperation teams. I first noticed this pattern when fishers who worked in teams registered exactly the same catch under the name of both boats consistently (e.g. Evo-Gely 25.33 kg; Gely-Evo 25.33 kg). People from Dzilam Bravo later confirmed that teams were in operation. The cooperation agreement implies that the catch obtained by both boats in a particular trip is merged, and regardless of who caught more, the revenues are divided equally. Fishers working in cooperation teams appear also to share information about potential productive fishing grounds (J. Acosta pers. comm.). Composition of the teams appears to be very fluid in terms of partners, both within and between years.

In Dzilam Bravo in 1992, 14 boats were operating in cooperation (18% of the total). Only one team was made up of relatives, although some fishers teamed up with friends (R. Torres pers. comm.). Some boats among the 14 would switch partners from one trip to another, producing 17 different observed combinations. In 1993, the number of boats increased to 18, but only 12 combinations were observed, which means that some of the teams did not change partners as frequently as in 1992. New teams were created and some of the previous ones were dissolved. New boats adopted the cooperation strategy while 30% of the boats that cooperated in 1992 did not do so in 1993. Additionally, one team comprised three boats instead of two in this year. In 1992, a total of 1528 trips were undertaken by teams, and 1921 in 1993 (5% and 6% of the total each year respectively).

Fishers assert that windy conditions and variations in temperature promote the operation of the cooperation teams. As in many other tropical areas, temperature varied little in Yucatán throughout the year and this was confirmed looking at the values of the anomalies (differences between the maximum and minimum value) for this parameter (Figure 3.7a). On the other hand, wind fluctuations were more evident (Figure 3.7b). In both years, however, at least one team operated each month and not exclusively during the windy periods. I estimated the frequency of teams operating each year, and by cross-tabulation I compared this with wind speed. The number of teams increased when wind speed was above 40 km/hr and the number of trips undertaken by these fishers also increased significantly (Figure 3.7c, Table 3.6).

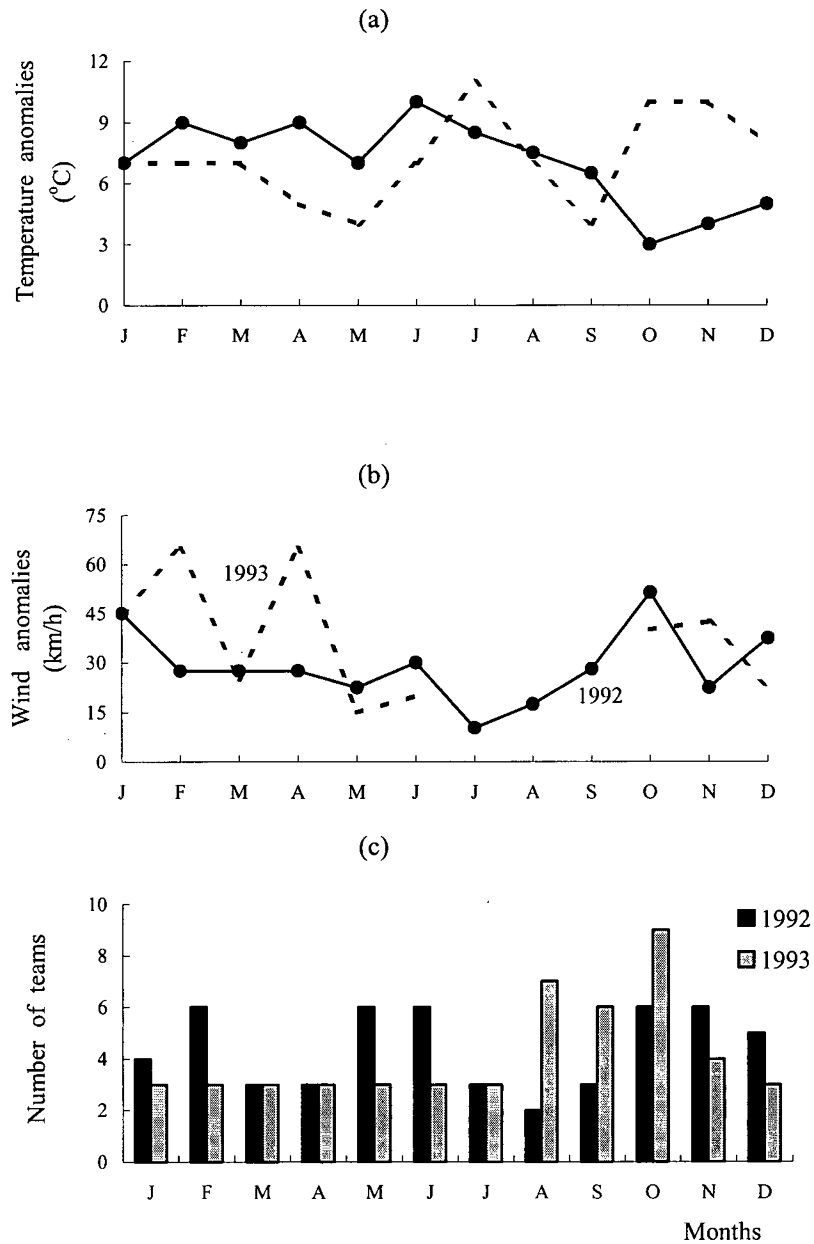

Figure 3.7. Monthly variation of: a) temperature and b) wind speed in Yucatán in 1992 and 1993. c) number of teams operating in Dzilam Bravo during the same period of time.

Table 3.6. Tabulation of number of trips undertaken in Dzilam Bravo by cooperation teams under the following conditions: wind >40 Km/hr and more than four teams in operation.

	1992			*1993*		
(>40 km/hr)	*>4 teams*	*<4 teams*	*Total*	*>4 teams*	*<4 teams*	*Total*
Windy	1300	279	1579	1300	279	1579
No-windy	0	342	342	0	342	342
Total	1300	621	1921	1300	621	1921
Chi-square(df=1) 871.01 P=0.001; Spearman's rho=0.05 (*) (2-tailed)						

If reducing uncertainty in the catches due to 'bad weather' was the main reason for creating cooperation teams, use of teams in July in 1993 does not show such risk-averse attitude as this month is one of the less hostile for the fishing activity. Moreover, diminishing variability in catches could be assumed to result from cooperation, regardless of the weather conditions. If that was the case, reduction of the coefficient of variation in the mean catch for cooperation teams was expected. Results of my analysis support this assertion in the case of grouper and octopus in both years, but not for lobster in 1993.

Table 3.7. Mean catch of boats working in cooperation and those who did not in Dzilam Bravo during 1992 and 1993 (Mann-Whitney P>0.01). N= cases, CV= coefficient of variation, Z= Mann-Whitney statistic.

	1992			*1993*		
	Grouper	*Lobster*	*Octopus.*	*Grouper*	*Lobster*	*Octopus*
Cooperation						
Mean	59.1	13.0	121.9	13.8	3.4	16.9
CV	108.0	30.0	53.0	20.1	316.0	202.0
N	144	39.0	65	339	339	339
Non-cooperation						
Mean	60.1	7.8	89.5	25.49	2.85	18.49
CV	209.0	123.0	213.0	358.0	262.0	399.0
N	2914	1438	419	3831	3831	3831
Z	-1.579	-0.355	-0.224	-1.555	-0.323	-0.227

It was expected that working in cooperation teams would result in higher catches than working alone. Significant differences in the mean catch were observed between fishers working in cooperation teams with those who did not (Table 3.7). Lobster and octopus catches were higher for the cooperation teams according to the seasonal patterns, but statistical differences were significant only for 'others' (Mann-Whitney Z= -2.37 and Z= -2.41 for 1992 and 1993 respectively; P= 0.01). Although the average catch of lobster for fishers operating in cooperation teams was higher in July in 1992, it is difficult to make conclusions based on this because of the small number of teams operating that month.

Begossi (1992) defines an active strategy when both expected catches and cooperative information define the next trip setting, and a passive strategy if fishers base their decisions only on their own information provided by previous trips. I contend, however, that a random strategy would be a passive strategy, but seeking information within one's fishing operation and others leads to an active strategy. For instance, I consider cooperation teams in Dzilam Bravo an active strategy used as a mechanism for facing uncertainty under environmental constraints in order to maintain at least an average catch to cover expenses. The fluidity with which teams are formed and dissolved throughout the season supports the idea of an environmental response, a hypothesis which was supported by the analysis undertaken here.

Cooperation teams have been in operation since 1990 in Dzilam Bravo (T. Castro pers. comm.). Blondin *et al.* (1981) reported cooperation of fishers in Dzilam Bravo for pelagic fishes because the length of the net required many men to operate them. Usually two boats would work together. Reference to the type of cooperation described in this study, however has not been reported before. Fishers do not openly express the use of this strategy with outsiders, but the tendency up to the present day is to increase the number of boats using this strategy (J. Acosta pers. comm.). Gatewood (1984b) states that social cooperation is attained only if those involved have a common or shared perception about how their objectives can be met under prevailing conditions. Thus, it could be expected that fishers act together as long as mutual benefits are perceived. Moreover, teams were not cohesive and consistent from year to year and within the same seasons

3.3.6. Fishing efficiency

Although fishers from the three ports target the same species and shift among them throughout the year, significant differences in fishing efficiency *(FE)* among fishers were observed (Kruskall-Wallis, Chi square =69.43, P =0.01.). Distributions were skewed for San Felipe and Dzilam Bravo, but not for Sisal (Appendix I.5). The highest value of *FE* was obtained in Dzilam Bravo and the lowest in Sisal in both years (Table 3.8). Within ports, efficient fishers in Sisal doubled the FE of those with the lowest score. In contrast, in Dzilam Bravo, the top fishers attained 10 times the value of those with the lowest index.

Table 3.8 Fishing efficiency (US Dlls/trip) of fishers from three ports of Yucatán during 1992 and 1993; CL= confidence limits at 95%, CV= coefficient of variation.

	Sisal		*San Felipe*		*Dzilam Bravo*	
	1992	*1993*	*1992*	*1993*	*1992*	*1993*
Mean	79.3	75.8	103.9	108.3	188.8	124.7
CV (%)	41.0	36.0	51.0	77.0	33.0	108.0
CL	21.7	22.3	35.0	28.9	34.5	46.9

In all ports, significant differences of *FE* among ports and across each year were also evident (Figure 3.8, Appendix I.6, Kruskall-Wallis, P =0.01). The higher values were observed from September to December in 1993 in Sisal and San Felipe. A slight reduction in fishing efficiency was observed in Dzilam Bravo, from 1992 to 1993 that coincided with an increase in the number of days fishing in 1993.

In the other ports, a more stable number of trips from year to year were observed. This coincides with the tendency of fishers to fish more days at the beginning of the lobster season (July-August). The increase in the number of days fishing was observed in that period in all ports, where around 30% of the fishers spent more than 15 days fishing per month (Appendix I.7). In the following months, this frequency dropped to 8 days in Sisal and San Felipe, and 5 days in Dzilam Bravo. Before the lobster and octopus seasons were open, most of the fishers were fishing between two and ten days a month. In Sisal, however, 15% of them remained very active between April and May (15 and 20 days per month). Similar patterns were observed in 1993 for each port (Appendix I.8).

I assumed that the effect of cooperation teams and the use of large boats might have some influence on the high values of *FE* in Dzilam Bravo. However, the elimination of fishers operating in cooperation did not change significantly the mean or the distribution of this variable. Boat size appears to have more impact on the average values of *FE* than cooperation teams (Table 3.9). However, the combination of large boats and cooperation teams was difficult to differentiate, as links exist between them. Some fishers that own big boats also work in cooperation teams.

Table 3.9. Effect of elimination of large boats (LB) and cooperation (Coop) in Dzilam Bravo during 1992 and 1993 on fishing efficiency compared with that from the small boats only.

	Large boats	*Cooperation*	*Non-coop*	*Small boats*	*Overall*
1992					
Mean	641.8	112.5	193.7	43.2	188.8
CV	1.8	1.4	3.34	20.6	3.3
N	235	58	908	731	966
1993					
Mean	128.6	137.9	93.4	87.4	124.7
CV	1.8	1.41	1.4	1.6	1.5
N	334	126	677	469	803

Monthly patterns of fishing efficiency did not coincide with the catch per unit effort (CPUE) trends. Even though from July to November the fishing efficiency attained higher values in both years, in July the CPUE reached the lowest values for both years (Figure 3.8). Increase in the CPUE was observed from September to November, when more octopus was captured. Hence, octopus and demersal fishes add volume, while the lobster adds value, and these effects are reflected in the CPUE. Furthermore, it is important to keep track of catch rates and fishing efficiency, as both provide different information about the fishing activity and practices of the fishers. The results derived from this analysis indicate that higher economic fishing efficiency does not necessarily coincide with high catch rate. Both components have to be considered in evaluating the impact of fishing effort on the resources. In these fisheries, as noted before, it seems that fishing effort is guided by the landed value more than by the catch *per se*.

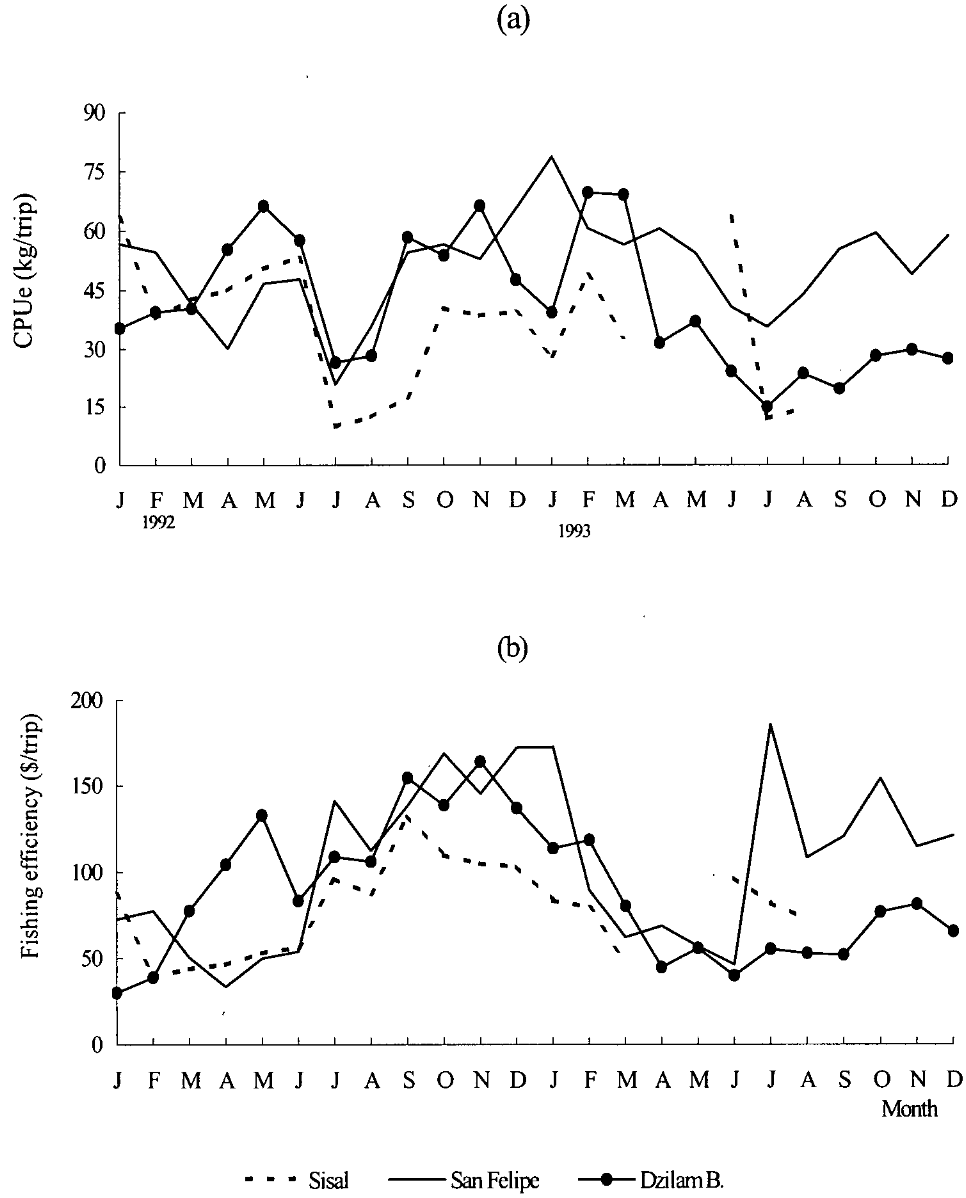

Figure 3.8. Monthly patterns of a) catch per unit of effort and b) fishing efficiency in the three ports during 1992 and 1993.

3.4. Discussion and conclusions

Two basic questions were posed at the beginning of this chapter regarding the homogeneity of fishers that operate under the same management regime and share common features. Seasonal differences of the fishing patterns among and within ports in both years exhibit the heterogeneous nature of small-scale fishers'operations on the Yucatán coast. Analysis of daily catch data as well as additional information allowed me to identify three main strategies observed by fishers in the ports analyzed: 1) switching behavior among alternative species and gears, 2) working in cooperation teams, and 3) changes in differential fishing efficiency.

Switching among alternative species was common in all ports, with no clear specialization of fishers regarding the target species and the gear used. However, a tendency to catch more lobster in San Felipe, octopus in Sisal, and demersal fish in Dzilam Bravo was observed. In 1992, this may have been related to fishers' skills and characteristics of the fleet. Although fishers from all three ports are constrained by the same factors (regulation, resource abundance, and environmental conditions), less experienced fishers from Sisal may prefer a less active and risky fishing method such as the one used for octopus.

Bio-geographic factors have been suggested as elements structuring the activities different groups of fishers can have access to, and also define their ability to change and adapt their current activities in response to new conditions (Apostole *et al.* 1985; Smith and Hanna 1993). That is, fishers optimize their labor not only by harvesting different resources under changing environmental conditions, but also depending on their 'own resources'. I define these resources in terms of their skills, boat characteristics, personal targets, expected income, and demands from the community to which they belong. For example, apparent inefficient utilization of a valuable species like lobster during the whole fishing season by fishers in Sisal may initially look unreasonable. However, it may be safer for those with limited skills to dive.

On the other hand, fishing resources that are not homogeneously distributed in space, time and seasonal patterns of movement, such as migrations, homing, and concentration while feeding or reproducing, determine spatial and temporal availability of the resources for different groups of fishers. For example, some fishers in Quintana Roo set nets at the northeast of the Yucatán shelf to intercept the along-shore migrations of lobster, ensuring high catches (Arceo *et al.* 1997). However, in places like Sisal this is not possible as the lobster moves from west to east. Likewise, Arreguín-Sánchez *et al.* (1997) report that fishers in Yucatán fish heavily on groupers when they aggregate to reproduce (northeast), or to feed (southeast), resulting in high catches during those periods especially in ports near to the east coast like Dzilam Bravo.

The cooperation teams in Dzilam Bravo seem to pay off, despite only a small proportion of fishers using the strategy. At this stage, the overall effect of these teams on the average catch of the whole fleet appears to be insignificant, but it seems to affect the coefficient of variation of the mean catch. The multidimensional nature of the fishing effort is indeed clear here. Although the elimination of large boats had more impact on estimated fishing efficiency, some fishers owning those boats also operated in cooperation teams.

As no additional information was available regarding the cooperation teams, I was unable to undertake a deeper analysis, nor identify clearly other factors influencing this strategy besides the apparent response to environmental constraints. In this regard, future research could focus on questions such as: a) how cooperation produces benefits other than covering expenses or reducing uncertainty? ; b) why only few fishers participate in those groups?; c) how are the teams defined in terms of composition and social attributes?; d) how does kinship operates?, e) why the teams are not stable?, and how this behavior is linked to the behavior of the fishing resource (movements for example) in this region .

Whereas the highest fishing effort was observed in San Felipe in 1992, the mean catch per fisher and fishing efficiency was higher in Dzilam Bravo. This could be due to the smaller number of fishers in the second one, the operation of cooperation teams, use of larger boats by some fishers, or a combination of all of these. Even though from 1992 to 1993 an increase in fishing effort in Dzilam was accompanied by changes in mean catches and fishing efficiency of fishers, it remained higher than in other ports, but decreased from one year to the next. The same pattern was observed for the CPUE. In contrast, in San Felipe the fishing pattern from one year to the next was maintained. Limited information in Sisal for the second half of 1993 reduced the possibilities of comparisons between years.

It was clear that fishing effort followed a similar pattern as landed value rather than the one of catch, which exhibited the economic benefit expected by investing time and capital fishing. The economic motivation of earning a living from marketable commodities indeed may influence fishing behavior, but the extent to which this can happen would be defined by fishers' personal goals or anticipated catch, available alternatives and particularly on the abundance of the resources.

On the other hand, decrease in catch per unit effort (especially at the opening of the lobster season), as a result of an increase in the number of trips at that time, suggests potential externalities, such as interference from other boats on the fishing grounds. Externalities in this context are defined as the effect that one boat (or person) has on someone else's interest (catch, properties, etc.) without accounting for it. For example, if the number of fishers on the fishing grounds increases, some fishers have to wait until they are free to search and fish in the area. Alternatively, they could move to another area or moving further from their homeport. This involves more time searching and consequently increases the fishing costs (see Knudsen 1995; Seijo *et al.* 1998). Fishers in San Felipe have no specific fishing grounds on which to fish grouper or octopus. However, fishing lobster requires searching larger areas, hence the rule of "first-come-first served" operates there. That is, the fisher who arrives first has the right to fish in the area, and other fishers have to maintain a minimum distance of 100 m from the first to arrive (R. López pers. comm.). This system works as long as the number of fishers and boats operating in the area does not increase. As more people search the grounds close to the landing port, these areas are fished out faster, forcing fishers to move farther as the fishing season progresses.

To summarize the results obtained in this analysis, I show the strategies identified for each of the ports in Table 3.10. I also present the goals assumed as 'potential' factors that motivate fishers to operate in a particular way. Constraints such as resource abundance, regulations, and environmental conditions are considered to affect all fishers equally. It is important to emphasize that the fishing process is dynamic, and the combination of fishing strategies may vary from fisher to fisher and through time for individual fishers. The permanence of a particular strategy will depend on factors such as whether the 'objectives' are met, how constraints can be overcome, fleet characteristics, and the background of fishers.

Table 3.10. Summary of fishing strategies of small-scale fishers identified from three ports of Yucatán in 1992 and 1993.

Goal	*Decision*	*Strategy*	*Where*
Maximize catch	Increase days fishing? Increase boat-power?	Improving fishing efficiency	Dzilam Bravo San Felipe
Maintain average catch	What species to target?	Switching behavior	Dzilam Bravo San Felipe Sisal
Reduce uncertainty	Fish alone or fish in team?	Working in cooperation teams	Dzilam Bravo

In small-scale fisheries, where operations usually take place on a daily basis, fishers have to make choices every day. The decisions can be nested in some cases, such as deciding whether to go fishing or not; which species to target, and whether to work alone or in a 'cooperation team'. Fishers' decisions are based on their goals and constraints. For example, given adverse conditions it may be unprofitable to go fishing when fishers could make better use of their time. Goals can vary from fisher to fisher under different circumstances and expectations. For instance, fishers can sometimes give up efficiency for 'secure average catch' or combine a series of strategies such as operating in a team, increasing efficiency, and switching target species in order to increase catches and reduce uncertainty. This appears to be the case with some fishers from Dzilam Bravo.

Switching behavior and cooperation were strongly seasonal, whereas fishing efficiency reflected a more 'human oriented' action, including modifying boat characteristics or increasing the number of days fishing during a particular fishing season. These aspects are particularly important when the implications for management are considered. Determination of the elements associated with the strategies could provide useful information in evaluating how fishing practices affect resources.

Summary

The main findings derived from these analyses allowed me to identify switching behavior among alternative species in all ports, fishing cooperation teams, and changes in fishing efficiency among and within ports. All of those measures indicate significant heterogeneity among fishers. Daily switching among alternative species was observed to occur in clusters in Sisal, i.e. when most of the fishers switched almost simultaneously, but this was not so evident in San Felipe and Dzilam Bravo. This pattern of behavior is associated with the unwillingness of fishers in Sisal to accept much risk as elsewhere. Specialization was not confirmed statistically, although fishers appear to have preferences for particular species. These preferences could be the result of availability of the resources, price of the species, fishers' skills, experience, or a combination of them all. Although no specialization was demonstrated, the preference observed might be the base for the folk concept of 'good divers' claimed by fishers from San Felipe. Cooperation teams were identified in Dzilam Bravo. Fishers state that the origin of this strategy is to deal with uncertainty under constraining environmental conditions. This assertion was confirmed analyzing weather data. Finally, maximization of catch, reduction of uncertainty, and maintenance of average catch are proposed as potential goals that could promote fishing strategies. Constraints related to management, environmental conditions and market appear to concern most fishers. Analysis of daily catch provided valuable information about fishers' strategies. This study could be expanded in order to obtain information regarding fishers goals when developing a particular strategy or changing strategies, as well as answering some of the questions that arose from this study

CHAPTER 4

Fishers' performance and relative importance of factors determining catches and profitability

4.1. Introduction

In many fisheries the distribution of the catch among fishers reveals differences in catch rates. That is, in a given time or for a given effort some people appear to catch more than others (Hilborn 1985; Abrahams and Healey 1990; Cabrera and Defeo 1997). This variability has been associated with several factors. For example, technological improvements of the boats or gear modifications have been associated with the increase in catching power and a reduction in time searching (Pálsson and Durrenberger 1982; Christensen 1993). Fishers' skills have also been suggested as important elements that contribute to differential catch rates (Forman 1967; Acheson 1981; Acheson 1996; Gaertner *et al.* 1999). Additionally, bio-geographical conditions that affect the behavior of the resource have been considered to be reflected in fishing patterns and catch rates (Healey and Morris 1992; Puga *et al.* 1996; Sullivan and Rebert 1998).

Under this context, fisheries scientists have given more attention to changes in the distribution of fishing effort and catchability due to technological modifications over long-term than to changes in catch rates within a fishing season. Special attention has received the identification of a 'boat type' in order to standardize fishing effort when defining management schemes (Clark and Kirkwood 1979; Hilborn and Ledbetter 1985). Durrenberger (1993) states that it makes little sense trying to reduce fishing pressure from a fishery by removing boats if other variables, such as skills, influence catch. If, on the contrary, fishers' expertise has a smaller effect than technology, it would make more sense to regulate fishing pressure, for example, by imposing quotas on boats according to past performance. However, both components might be present, and hence a combination of management strategies has to be considered.

Fishing is not only a commercial activity, but also a very uncertain and competitive one where fishing practices seem not only associated with biological and technological factors, but also with how many fishers operate in the area. Furthermore, the way individuals perform will be reflected in the distribution of the catches among those sharing the resources.

In recreational fisheries, the analysis of the seasonal distribution of the catch in the short-term, based on estimation of performance indexes has enabled comparisons of patterns of behavior among anglers and facilitated evaluations of the impacts of regulatory schemes upon fishers (Baccante and Colby 1991; Baccante 1995). In commercial fisheries, although the influence of seasonal changes on individual fishing patterns has been acknowledged (Sampson 1992; Sullivan and Rebert 1998), these changes have not been explored in depth. This issue becomes especially relevant, in small-scale fisheries, where fishers have to operate mainly on a daily basis.

In this chapter, I undertook comparative analysis of individual catch rates and explored the contribution of a combination of variables on the catches and fishing efficiency (in terms of landed value) of small-scale fishers in the short term. To do so, I estimated an index of fishers' performance and compared seasonal patterns among the three ports. Additionally, I carried out a multiple regression analysis to explore the influence of various factors on the catches within a fishing season. From the previous chapter, there were significant differences among and within ports in fishing efficiency; thus I analysed each port independently.

In Yucatán, fishers have made comments in informal conversations about what they consider the most important factors that define their catches. Among them, were mentioned: types of gear, boats, days fishing, luck, fishers' experience, and knowledge. Based on the fishers' statements and literature review, I assumed catch rates and landed value of the catches are associated with technological, human, and environmental conditions in a way that high catches and high revenues will result from trips undertaken by fishers:

a) with large boats and high engine power;
b) with high fishing experience;
c) targeting the most profitable species on each trip.

4.2. The data

For this analysis, I used daily catch data from 20,000 individual fishing trips carried out by 377 fishers operating in three fishing ports during 1992 (the same data base from 1992 used for the analysis in Chapter 3). Data were summarized on a daily and monthly basis by individual fishers. Monthly prices of the different species were used to estimate the landed value. This information was used to compute a fishing performance index and as an input in a matrix for regression analysis. This matrix includes landed value and total catch per trip as alternative dependent variables. The explanatory factors considered were: boats' characteristics, fishers' attributes, species targeted, and environmental seasons.

4. 3. Fishers' performance index

Every time small-scale fishers in Yucatán go fishing, it seems to be common for them to evaluate how well they have done compared with the rest of the fishers in the community (R. López pers. comm). This behavior has also been reported in other fisheries (Cove 1973; Gatewood and McCay 1990). Thus for purposes of comparison of fishers' performance, an index was estimated according to function (4.1). Hilborn and Ledbetter (1985) use this function to evaluate performance of boats. In this case, the performance index of fisher k in port z in trip n (P_{kzn}) was compared with the one of fishers in the port he operates during the same period.

$$P_{kzn} = \frac{1}{n} = \sum_{n=1}^{N} (C_{kzN} - \overline{C}_{ztn}) \tag{4.1}$$

where: N is the number of trips per month t, n corresponds to the daily trips of individual fisher, C_{kzn} is the catch of fisher k in trip n in port z, and $\overline{C}_{ztn}$ is the average catch per month of all fishers in each port. Comparative analysis between the ports was performed after.

The rate of return for fishers can be measured in terms of catch or profitability, depending on what they are trying to achieve (Robinson and Pascoe 1997). As species vary considerably in price, especially lobster, catch composition varies notably in terms of value (see Chapter 3). Thus, I used both catch and dollar value in the estimation of alternative forms of a performance index. In the case value, catch (C) in equation (4.1) is substituted by landed value (LV), which was calculated by species and summarized by trip (for details about the computation of this variable see Chapter 3).

The estimated fisher performance indexes in each port were compared by means of the Kruskal-Wallis test (Siegel and Castellan 1988). Additionally, I defined three categories of this index for comparison: below average (BA), average (A), and above average (AA). To ensure that the fishers allocated were different, the categories were defined according to the quartiles of the performance distribution for catch and landed value as follows: BA=>30%, A=30-60%, and AA=<60%. This selection was defined after testing different combinations within different ranges of the quartiles until the differences among the categories were statistically significant in each port (Kruskal-Wallis test). I want to emphasize that the scale proposed here was made only for purposes of comparison. If we are trying to see fishers in a less restricted way, putting them into a cage of scales or indexes may sound like going backwards. However, here the idea was mainly to evaluate differences having a reference point, in this case as 'average' as the fishers compare themselves with other fishers and define if they caught more or less than the majority. That does not mean that an 'average fisher' exists or that values above or below the average have a positive or negative meaning.

4.4. Multiple regression analysis

I performed multiple regression analysis (MRA) to identify the variables that contribute to the variation of catch or landed value per fisher on a monthly basis (Analysis A) in each port. I used a data matrix of daily catch summarized by individual fisher and undertook the analysis separately for each port (Figure 4.1). I included numerical and categorical variables as the explanatory. In analysis B, additionally, I also applied MRA, but splitting the data matrix by the performance categories using the same variables, and ran the analysis by category in each port. Finally, I compared the results to evaluate if the variables identified in Analysis A remained valid in analysis B.

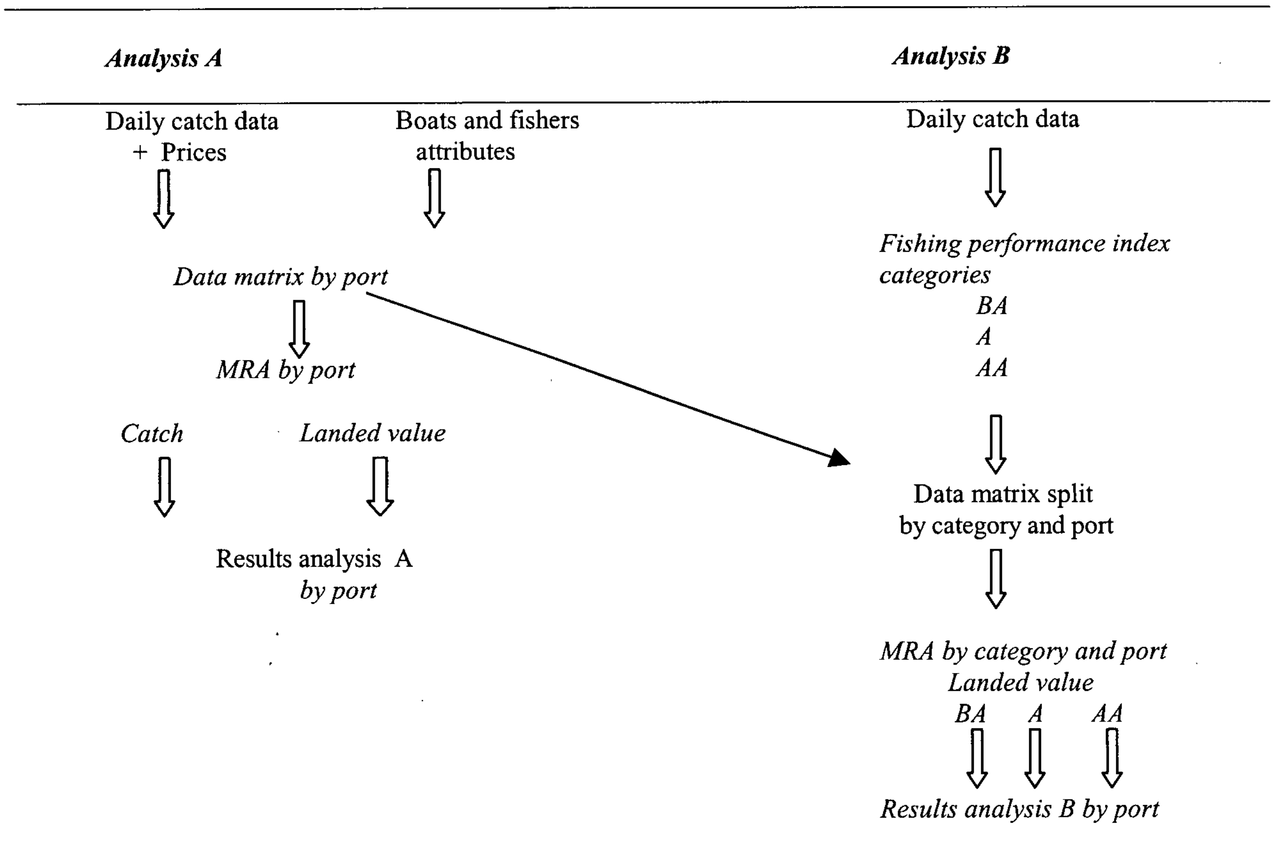

Figure 4.1. Synoptic approach followed for the regression analysis. Fishers' performance Categories are defined as: BA (below average), A (average), and AA (above the average).

4.4.1. The variables

In the present study, I assumed that catch (C) and landed value (LV) are a function of indicator variables represented by a technological effect (T), a human component (H), and seasonality (S). The variables included in each component are:

Human component: numerical and categorical variables were included in this component. For the former, monthly trips per fisher, fishers' age and experience were incorporated in the analysis. As age and experience are correlated variables, they were analyzed separately. In Dzilam Bravo, working in cooperation was also considered and included as a dummy variable.

Technological component: only numerical variables, such as length of the boat and engine power were included. Only in a very few cases, information about other attributes of the boats such as the storage capacity, width, age of the boat and motor was available; being incomplete, they were not included in the analysis.

Seasonal component: In this case, two sub-components were considered, one related to the species targeted, either because of regulation or because of their availability. The second component was associated with environmental conditions.

Target species. categorical variables were defined for target species. These variables were coded as dummy variables. These variables (also termed indicator variables or binary variables) can only assume values of zero and one, and can be used to discriminate between categories of a predictor (see von Eye and Schuster 1998 for details). The predictor was defined with five levels: grouper, lobster, octopus, others and combination of species. The last level corresponds to those trips in which more than one species was caught. Grouper was selected as the indicator category (*IC*), i.e. when a dummy variable is set at zero and is used as the reference category. The values of coefficients for each category of the dummy represent the effect each one has on the dependent variable, compared with the reference category in the estimation of a particular outcome. Grouper was chosen because fishers have unrestricted access to this species under the current regulations, and thus was always available. As prices affects landed value, the categorical variables defined for target species were based on the proportion of each species in terms of weight and dollars for catch and landed value respectively.

Environmental conditions a dummy variable with three levels was used for this component based on environmental seasons: windy season (November to February), dry season (March-June) and rainy season (July-October). These seasons are easily identified in tropical areas unlike the typical springwinter pattern more common in temperate regions. In this case, the windy season was selected as the indicator category of the dummy.

4.4.2. Selection of significant variables and parameters estimation

The following steps selected a subset of the variables initially proposed:

a). As a general linear model was chosen for this analysis, I applied logarithmic transformation to the numerical variables when required, and carried out a normality test afterwards using a Normal probability plot (Q-Q plot). This plot contrasts the quartiles of the observed variable and a hypothetical variable with normal distribution. One advantage of this method is that it allows examination of large data sets, (see examples of non-transformed variable and one variable after transformation in Appendix II.1). If points cluster around a straight line, the data analyzed come from a normal distribution (Norusis 1997).

b). To find the significant model components in the regression analysis, I tested several methods (stepwise backward elimination and stepwise forward) before selecting one of them. As consistency in the results with both methods was observed, hence the backward method was selected for the final analysis using the Statistical Package for Social Science (SPSS V.9, Norusis 1997). The selection of variables with this method is based on the relative significance of each coefficient compared with those from the prior model before the selection of the final model. Ordinary least square criterion (*OLS*) was used for parameters estimation (Norusis 1997; vonEye and Schuster 1998). Partial F-test statistics, the standard error of the estimate, and the adjusted coefficient of determination (R^2) were used as indicators of goodness of fit (see Achen 1982; vonEye and Scuster 1998).

Identification of outliners and influential observations was customarily done by observation of the distribution of the residuals when assessing goodness of fit and sensitivity of the coefficients. Normal distribution of the residuals confirmed that the linear model after transformations was appropriate for this analysis.

4.5. Results

4.5.1. Performance index

Table 4.2 shows the proportion of fishers that fell in each category defined by the performance index: below average (BA), average (A), and above average (AA).

Table 4.1. Percentage of fishers in each performance category by port

Performance category	Sisal	San Felipe	Dzilam Bravo
Catch			
BA	18.7	31.4	33.1
A	56.0	36.7	43.8
AA	25.3	31.9	23.1
Landed value			
BA	9.8	25.7	55.2
A	75.3	37.1	14.3
AA	14.9	37.2	30.5

Fishers in Sisal was observed given this index. In this port about 50% of fishers fell within category (*A*) for performance of catch and 75% for landed value. In contrast, in San Felipe, fishers split almost equally among the three categories in both cases (catch and landed value). However, a slightly lower proportion fell below the average for landed value. In Dzilam Bravo, about 45% of fishers were within the average for catch, but only 15% did for landed value in this category. These results might look contradictory at first sight. Although almost half of the fishers in this port fell within the category (*A*), their catch would not necessarily include species of high value. Those that attain high revenues could do so because of a high volume of a species of low value, a small but significant amount of profitable species, or a combination of both.

Although the proportion of fishers within categories did not vary much for San Felipe and Dzilam Bravo the differences among all ports were significant (see appendix II.2. Kruskal–Wallis test, P= 0.05). The monthly patterns of the performance index (including confidence limits at 95%) also exhibit a wide range of variation in this index in Dzilam Bravo compared with the other ports, especially regarding landed value (Figure 4.2, left panel). During the closed seasons for lobster and octopus, the range of variation for the index in terms of catch was smaller than during the open season. This pattern was observed in all ports.

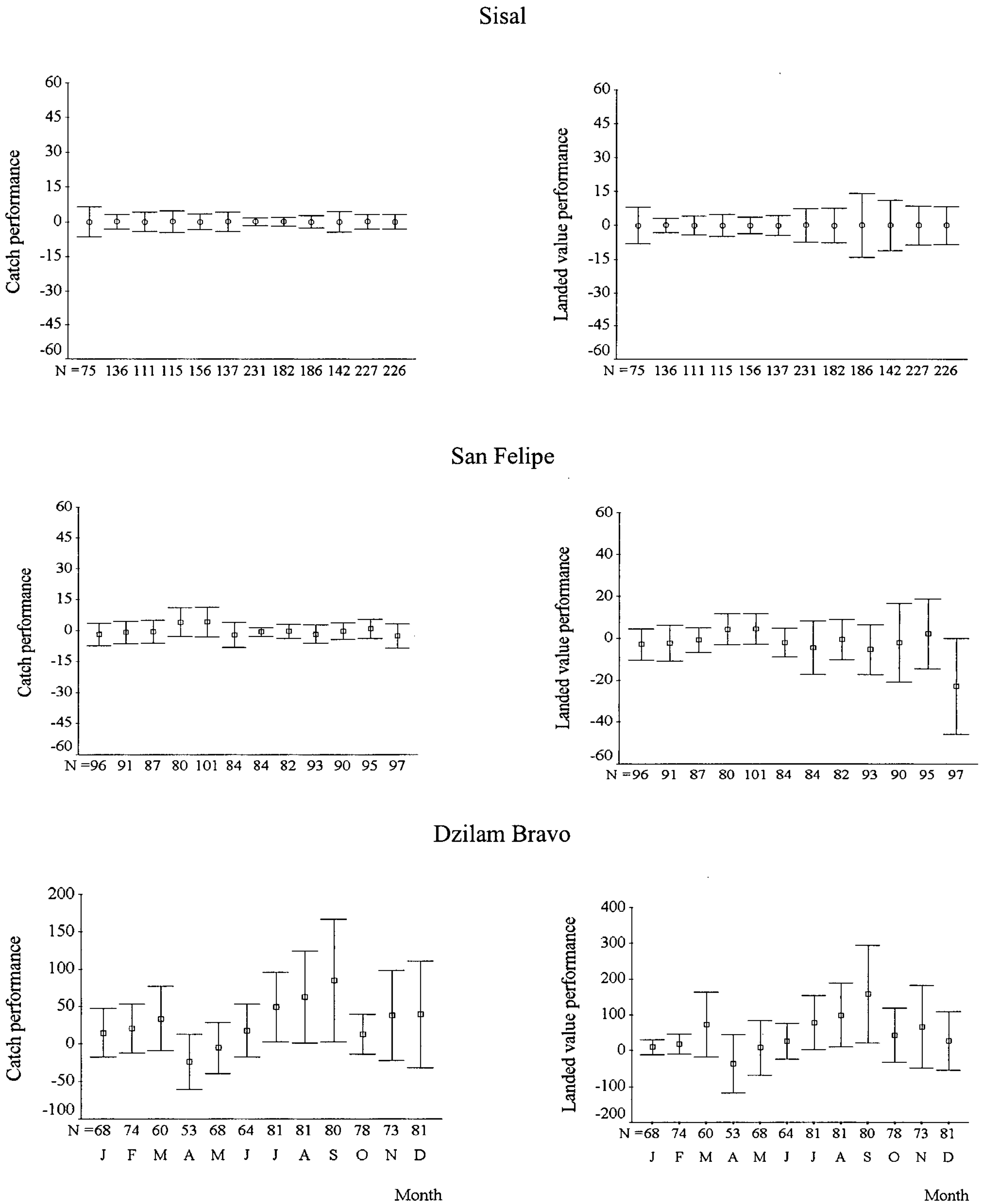

Figure 4.3. Monthly variation of fishing performance in terms of catch (right panel) and catch value (left panel). N in the horizontal exe indicates the number of cases. The confidence intervals were estimated at 95%.

I expected to find differences among the three categories of fishing performance in terms of the attributes of the fishers, characteristics of the boats and species targeted. However, the range of values for some of the initial variables proposed was fairly narrow (Table 4.2). Experience and age were not that different among fishers for each category. Boat size and power engine showed slight differences, and trips were higher for average performance in Sisal and San Felipe, but not especially so. Notice that although boats in Sisal are the same size, two types of engine are used, and fishers that fell in the category of *AA* used bigger motors. This does not seem to make a difference for the other ports, although fishers with larger boats in Dzilam Bravo fell in the category *AA*.

Table 4.2. Mean values of attributes of fishers and boats for different performance categories and range of variation. Average for trips is on a monthly basis.

Port	*Performance* category	Fishers' experience (years)	Fishers' age (years)	Boat size (m)	Engine power (HP)	Trips (days)
	BA	4	36	7.6	55	11
Sisal	A	4	35	7.6	55	13
	AA	4	33	7.6	60	17
	Range	1-8	21-45		55-60	3-27
San Felipe	BA	7	32	7.5	44	7
	A	7	33	7.5	47	10
	AA	7	33	8.6	55	9
	Range	1-18	21-56	7.5-8.6	20-60	1-30
Dzilam B.	BA	15	33	7.6	44	8
	A	12	34	7.8	55	7
	AA	15	35	10	60	16
	Range	1-36	15-50	7-10	20-60	4-22

Although the monthly number of trips does not differ for each category, the range was different in all ports. The range of variation from one category to another for these variables was smaller in Sisal and highest in Dzilam Bravo, especially between categories (*AA*) and (*A*). This seems to be reflected in the catch per unit effort and landed value per trip in the different categories. For instance, in Dzilam Bravo even though a higher percentage of fishers fell in the BA category in terms of catch than those in Sisal and San Felipe, mean CPUE and fishing efficiency for fishers in Dzilam Bravo were higher for the *AA* category in this port. The range of variation within each category is also notable in this port. For example, mean values for Sisal in the category (*AA*) are almost half of those obtained in Dzilam Bravo (Table 4.3).

Table 4. 3. Range of variation of catch per unit effort and fishing efficiency by performance category.

Port	*Performance* category	*CPUE (kg/trip)* Max	Min	*Fishing efficiency ($/trip)* Max	Min
	BA	58.5	3.6	100.5	25.7
Sisal	A	60.0	17.9	181.6	36.3
	AA	94.8	25.2	139.8	44.5
San Felipe	BA	49.8	2.4	187.9	4.23
	A	72.4	7.3	373.1	19.5
	AA	256.4	28.2	589.1	40.9
Dzilam B.	BA	62.6	1.3	404.4	2.2
	A	119.6	1.4	738.7	9.0
	AA	1679.0	55.3	2532.3	48.5

Despite that mean age and experience of fishers did not vary much for each category, these variables were kept for the regression analysis. The criteria for deciding which variables would be included in the analysis from the initial set proposed were based on: theoretical importance, statistical significance, and potential of the variable to be compared under the same or different design for the future (Achen 1982). It has been suggested in the literature that experience can be an important element in terms of how much each fisher catches (Pálsson 1988; Durrenberger 1993). Significant correlation coefficients of age and experience with catch and landed value were observed for San Felipe and Dzilam Bravo (see Appendix II.3). Given these elements, it was considered convenient to incorporate the variables in the regression analysis and to decide later whether to maintain or eliminate them if supported by further analysis.

4.5.2. Multiple regression analysis assuming all fishers perform equally (Analysis A)

In Sisal, trips followed a normal distribution, in contrast to San Felipe and Dzilam Bravo, where the distribution of trips was skewed and a logarithmic transformation was found appropriate. In all ports, the same treatment was required for catch, landed value, boat size and the engine power. Boats in Sisal are all the same size, thus they were eliminated from this analysis. Age and experience of fishers fit a normal distribution.

Results from the MRA are presented in Table 4.4. Only cases where the regression coefficients were different from zero, i.e., the variables that made significant contribution to changes in the dependent variables (catch or landed value) are included. The standard error of the coefficients and the summary of the statistics of the regression are shown in appendix II.4. A scatterplot of standardized residuals and the dependent variable shows that a linear model with the respective transformations was appropriate (see example in Appendix II.5).

The results of the regression indicate that catch and landed value were strongly related to the number of trips in all ports, this variable was never lower than 0.5. This result is expected when dealing with small-scale fisheries; as already been mentioned, these types of fisheries are characterized by labor intensive inputs (see Agüero 1992; Jeanning and Polunin 1996). With a few exceptions, all other variables have much lower coefficients.

Table 4.4 Standardized coefficients from multiple regression analysis (A) for catch and landed value in the three ports. Boats in Sisal were not included in the analysis; trips in Sisal were not transformed to logarithmic scale. N/A= Not applicable

	Catch			*Landed value*		
Variable	*Sisal*	*San Felipe*	*Dzilam Bravo*	*Sisal*	*San Felipe*	*Dzilam Bravo*
Constant	5.854	-4.72	-2.34	6.32	-6.57	-0.71
Fishers' experience			0.23			0.17
Fishers' age		-0.14			-0.14	
Ln Boat size	N/A	0.14	0.13	N/A	0.14	0.07
Ln Motor power		0.16	0.15		0.15	0.15
Ln Trips	0.56	0.77	0.70	0.62	0.59	0.56
Species						
Lobster						0.09
Octopus			0.10			0.07
Others			-0.09		-0.06	-0.11
Season						
Rainy	-0.51	-0.18	-0.23	-0.39	0.08	-0.21
Dry	0.21	-0.15	-0.17	0.17		0.19
R^2	0.70	0.68	0.66	0.53	0.70	0.62

In Sisal, only the coefficient for trips and weather were significantly different from zero. That is, catch and landed values were related mainly to how often fishers went fishing and limited or favored by environmental conditions. It is important to recall that the default or reference category for this dummy variable was the windy season. In this port, the rainy season (July-September) has a negative sign and the dry season (March-Jun) a positive sign, compared with the reference category. This does not agree totally with the expected results for these variables, as positive coefficients were expected in both cases when compared with the windy season. Wind imposes limitations on fishing such as generating turbidity which affects the lobster fishery given the fishing method (diving) or sudden change in wind direction ("Chikinic") can represent a real treat for the safety of fishers. Strong winds coming from the north ('Nortes') can limit and even shut down the fishing activity.

Although age and experience were correlated to catch and landed value in San Felipe, the age of fishers was significant, but experience was eliminated from the regression analysis because the coefficient was not significant. This result supports those described in Chapter 3. This may be related to the type of fishing method used and the effort and skills involved in using a particular gear such as the one for lobster in these fisheries. Durrenberger (1993) found similar results in a fishery in Mississippi where some fishers assert that older fishers 'cannot push as hard as younger fishers', i.e. the latter can spend more hours fishing than can the former.

Additionally, boat attributes (size and engine power) and number of trips, were also significant variables in San Felipe. Environmental conditions also contributed to the variance of the dependent variables. In contrast to Sisal, in this case, rain has a positive value when the dependent variable was landed value. This period comprises the opening of the lobster season and high catches of this crustacean were recorded at this port in 1992.

In Dzilam Bravo, boat size, trips, and engine power were significant. Fishers' age was not significant in the analysis for this port, but experience was. This is not a surprising result, as in this port fishers have more experience fishing than in the other two, and it was expected to be reflected in this analysis. Lobster was not significant for catch, but it was for landed value, although with a very low contribution. On the other hand, octopus showed a positive coefficient and 'others' a negative coefficient when related to the reference category for species (grouper). Working in cooperation was not significant in the analysis. As mentioned in Chapter 3, the number of trips undertaken by fishers working in cooperation teams comprised only 8% of the total. The low proportion may therefore not be sufficient to show a significant contribution in this analysis, even though it appears to be rewarding for the fishers using this strategy.

4.5.3. MRA splitting the sample by performance category (Analysis B)

In this section, I selected landed value alone as a dependent variable to compare the analysis by performance category with the overall (Analysis A). The reason for selecting this variable was that it exhibited greater variation by port than did total catch. So the sample in each port was split by performance category. The regression analysis was done using the same methods as in the former analysis. Results are presented in Table 4.5 and condensed for practical purposes in Table 4.6 (only signs of the coefficients). The summarized results of the regression analysis are shown in appendix II.6.

Table 4.5. Standardized regression coefficients (STDC) and standard error (SE) from *regression analysis (B) for landed value as dependent variable, split by performance.*

Sisal

	Below average		*Average*		*Above average*	
	STDC	*SE*	*STDC*	*SE*	*STDC*	*SE*
Constant	6.15	0.17	6.51	0.12	-15.16	7.12
Fishers' age						
Ln Boat size						
Ln Motor power					0.36	0.58
Trips	0.86	0.01	0.47	0.01	1.33	0.01
Species						
Lobster						
Octopus						
Other						
Season						
Rainy			-0.24	0.09	-0.29	0.15
Dry			0.45	0.07	-0.36	0.07

San Felipe

	Below average		*Average*		*Above average*	
	STDC	*SE*	*STDC*	*SE*	*STDC*	*SE*
Constant	5.14	0.10	-0.94	2.25	-7.61	3.19
Fishers' age					-0.20	0.01
Ln Boat size			0.06	0.03		
Ln Motor power			0.05	0.13	0.27	1.55
Trips	0.69	0.05	0.61	0.06	0.64	0.11
Species						
Lobster						
Octopus			0.17	0.06		
Other			-0.07	0.17		
Season						
Rainy	0.11	0.08	0.15	0.11	0.20	0.12
Dry	-0.28	0.08	-0.35	0.09	-0.32	0.44

Dzilam Bravo

	Above average		*Average*		*Above average*	
	STDC	*SE*	*STDC*	*SE*	*STDC*	*SE*
Constant	13.53	9.57	3.60	0.09	-15.51	1.07
Fishers' experience	-0.26	0.01			0.21	0.01
Ln Boat size	0.24	4.75			0.22	3.14
Ln Motor power			0.23	0.57	0.17	0.13
Trips	0.51	0.13	0.53	0.05	0.67	0.12
Species						
Lobster						
Octopus	0.24	0.26	0.38	0.16	0.25	0.16
Other					-0.28	0.31
Season						
Rainy			0.63	0.09	0.08	0.20
Dry	-0.19	0.21	0.34	0.11	-0.11	0.19

The regression analysis split by performance confirmed the importance of fishing trips with the higher standardized coefficient of all variables in all ports (higher than 0.5), regardless of the performance category. Most of the significant variables in analysis A were also significant in the present analysis. However, in Sisal engine power, which was not a significant variable in the former analysis turned out to be significant for fishers in category (*AA*). Reduction of the sample size when splitting by performance category might unmask the effect of this variable in the present analysis. Even though only two types of motors are used by fishers in this port, it appears that they could be important in the variation of the catches.

Table 4.6 Summarized results from analysis B. Signs are presented in brackets in the following sequence: *AA*, *A*, and *BA*.

	Sisal						*Dzilam B.*		
Variable	*BA,*	*A,*	*AA*	*BA,*	*A,*	*AA*	*BA,*	*A,*	*AA*
Fishers' age						(-)			
Fishers' experience							(+)		(+)
Boat size						(+)	(+)		(+)
Motor power		(+)				(+)		(+)	(+)
Trips	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Lobster									
Octopus					(+)		(+)	(+)	(+)
Others					(-)				(-)
Season									
Rainy		(-)	(-)	(+)	(+)	(+)		(+)	(+)
Dry		(-)	(+)	(-)	(-)	(-)	(-)	(-)	(+)

Coefficients for size of the boats and engine power were significant in the case of San Felipe and Dzilam Bravo. Additionally, the coefficient for fishers' age for the former and fishers' experience for the latter were also significant. The coefficients of the dummy variable for rain was positive in San Felipe and Dzilam Bravo, but not in Sisal.

Consistency in the significant variables in both types of analysis confirms the relevance of trips for the variation for catches and landed value. Even though different absolute values of the coefficients for the same variables differ between analysis A and analysis B for the same independent variables, however, those from analysis B fell between the confidence intervals of the former. Dummy variables are difficult to explain and compare because of the lack of consistency from one analysis to another.

I should note that, in contrast to other applications of MRA (prediction), in my study I used the tool exclusively for hypotheses testing. In both types of analysis, all variables explain above 50% of the total variability of the independent variables; high R^2, could result from the size of the sample in general terms. According to Achen 1992, a high number of cases can cause inflation of significant levels of R^2. However, in analysis B, when the ports were split by category, this value was high as well.

4.6. Discussion and conclusions

In an uncertain activity such as fishing, people compete for limited resources. Under these circumstances, fishers will try to obtain the best from their operations, not only in terms of catch, but also in terms of their reputation and position in the community. Cove (1973) reports that some captains in Newfoundland do not give too much attention to their total catches as long as they are higher than those of other skippers. Miller and Maanen (1979) state that fishers, like boats, acquire a reputation and reliability by their performance.

It is not my idea to propose specific categories to define a 'good' or 'bad fisher'. The use of a performance index here was used mainly for comparison purposes. In this regard, determination of fishers' performance and the variables related with catch rates and fishing efficiency could help to identify changes in exploitation patterns of fishers related to changes in fishers' operations and variations in the stock under exploitation. For example, an index such as the fishing performance could show trends of marginal catch rates of individual fishers in each port. So that when the performance of all fishers is affected, this would indicate that the fishery on a whole is in trouble. That is, a general increase in fishing efficiency could lead to a decrease in the individual yield once the optimal level of production has been attained regardless of how efficient a fisher is.

Now if some fishers catch more than others do, what determines these differences? Sampson (1992) states that catch and profits in a fishery depend on the technology employed, the human and capital resources, and the abundance and distribution of the stock under exploitation. He states that technology tends to evolve rapidly, having an impact on the flows of fishing profits, stability, and dynamic behavior of the whole system. However, he does not elaborate on what he defines as the human component in this process. Allen and McGlade (1986) assert that fishing contains two elements: 'discovery' and 'exploitation'. Thus, knowledge of the resource distribution and availability, combined with 'working hard' can result in high catches. On the other hand, Forman (1967) states that in a fishery in Brazil, fishing success has been associated with familiarity with fishing spots, youth, good health, sobriety, willingness to take risks and ability to command a crew.

In the present study, MRA analysis permitted me to partially test the hypotheses initially stated. I assumed that higher catches and profits would result from the use of large boats with high power, fishers with high fishing experience and preference for the most profitable species as a target in their trips. Although boat attributes were significant in San Felipe and Dzilam Bravo, results show the influence of trips were highly significant in all ports. Analysis A and analysis B confirmed these results, so that even for fishers in the category above average, the coefficients for trips were the highest. Yet, variability still remains unexplained in the three ports. The unexplained variability could be attributed to unmeasured effect; errors in the independent and dependent variables, or other factors associated to the 'human component' that have been termed as 'skipper effect' defined by several factors in addition to fishers' experience and/or age.

The 'skipper effect' has been widely discussed (Pálsson and Durrenberg 1982; Gatewood 1984a). Durrenberg (1993) states that the problem is that people define this concept differently. Some include effort as a dimension of the skipper effect and some do not. Thus, analyses that explore this effect may not be discussing the same phenomenon. In this study, I associated fishing trips with the human component, as the definition of number of trips undertaken would involve a decision depending on the constraints and goals of the fishers. Thus, I do not refer strictly to the 'skipper effect' as I assume several elements are involved within the definition of this concept. For example to disqualify the overlapping effect between the fishers and the vessels, it is necessary to assess the performance of the same skipper moving between vessels (see Hilborn and Ledbetter 1985). Other factors associated with every fishing trip, such as fishing gear, and not exclusively, linked to the boat, could help to identify overlapping or interacting attributes related to fishing effort, especially in small-scale fisheries. For example, Arceo and Seijo (1989) found that in the use of hookah' fishing lobster, time was the only significant variables associated with catches (with variability still remaining unexplained), compared to that of 'stationary fishing gears' such as traps, nets, and artificial habitats. For these gears, depth and time that the gear was immersed in the water were significant variables.

In the present analysis, lobster (the most profitable species) was significant considering the reference category only in Dzilam Bravo in the overall analysis, although with a small contribution. This was not the case, however when splitting the ports by performance category. The coefficient for octopus shows higher significance in this port and San Felipe in analysis B. Moreover, a combination of volume (octopus, demersal fishes, etc.) with high-value species (lobster) appear to make the major contribution across the year. This is confirmed by observation of catch and landed value seasonal patterns observed in Chapter 3.

The season and environmental conditions are considered relevant factors in the mode that the small-scale fishers operate. Strong winds have been reported as a limiting factor for fishing activities in small-scale fisheries (see Woznitzia 1992; Knudsen 1995). Differences in the coefficients between analysis A and B related with the dummy variables for environmental conditions did not show consistent results. This could be due to an overlapping effect of environmental seasons and fishing seasons given the regulations, as availability of the resource and regulations have a seasonal effect. Although I carried out an analysis adding two explanatory factors defined as access (bound by regulation), and weather (defined by environmental conditions), the standard error of the estimate in the regression analysis was large, and the residuals did not spread uniformly. The results were insignificant and this analysis was discarded.

This study focused on the analysis of within-season fishing patterns. Results from both type of analysis show consistency for most of the variables. Some differences were observed regarding the dummy variables. Thus assessment of different series of data and different ports in the same region could help to confirm the observed patterns. Results derived from the present analysis can help to provide insights into the understanding of small-scale fishers operations within a fishing season in the study area.

Summary

In the present chapter, I estimated a performance index in order to compare catch rates of fishers in the three ports analyzed. Given the categories of fishing performance defined, the results confirm the heterogeneity of fishers among ports and within ports. Although a small proportion of fishers fell in the category (AA) for Dzilam Bravo, the catch rate and fishing efficiency of these fishers can be markedly higher than the one observed in the other ports. This high variation in the performance among fisher within ports was also reflected in the seasonal patterns, where wide confidence limits indicate high variability of these indexes in that port.

The MRA, allowed me to test and support the hypotheses regarding the factors associated to variation of catches and profitability. Even though observation of the mean values of fishers with performance above the average suggested that boat and engine power are strongly associated with high performance, the number of trips undertaken by fishers were the most significant variables associated with this variation. Combination of lobster and octopus were more important in the definition of the catches as main target species along the year, than one species exclusively.

CHAPTER 5

Individual decision-making: selecting target species

5.1. Introduction

Bockstael and Opaluch (1983) assert that fishing effort has usually been considered as an aggregate of different variables, which respond to shifts in the non-zero level of profits within a fishery. This aggregate not only includes fishing gears and time, but also decisions of fishers, which affect the dynamics of the fleet. If the actual response of fishers at the micro-economic level is not considered, biased predictions of changes in fishing effort can result. At this level, knowledge related to variation by vessel class, changes in technology or other factors, could help managers to understand how fishers will respond to regulatory policies and other factors (Wilen 1979; Béné 1996; Dorn 1997).

Among the short-term decisions that fishers have to make, those related to selection of fishing location or target species, have been a topic of discussion from social, economic and biological perspectives. The suggestion that fishers' decisions respond to economic incentives (expected returns and its variability) has generated arguments both in favor (Andersen 1982; Bockstael and Opaluch 1983; Lane 1988; Tanaka *et al.* 1991), and in opposition (Jacobson and Thomson 1993; Smith and Hanna 1993). Robinson and Pascoe (1997) summarize some of the main arguments for and against the concept of fishers as profit maximizers and present empirical evidence for the assumption of profit maximization by fishers operating in the English Channel. However, they state that, although in their study the profit response of fishers does indeed hold, it does not totally explain fishers' behavior in the short term.

Models exploring fishing strategies, have been conducted under different temporal and spatial scales using different approaches, although they have focused mainly on patch selection by fishing vessels (Hilborn and Ledbetter 1979; Guillis *et al.* 1993; Dupon 1993). However less has been done in terms of evaluating the fishers decisions when selecting the target species (Opaluch and Bockstael 1984; Laloë and Samba 1991). Multivariate analysis (Pelletier and Ferraris 2000) and choice models have been used to explore fishers' choices between alternative sites for recreational and commercial fisheries (Bockstael and Opaluch 1983; Holland and Sutinen 1999; Gartner *et al.* 1999). Choice models to explore this issues, as far as I can ascertain, have not been reported in small-scale fisheries. In these fisheries, it is usually assumed that fishers are less motivated by monetary incentives than commercial fishers.

In Chapter 3, it was shown that switching among target species was a common practice in all the ports studied. In this chapter, I present a discrete choice model to analyze the individual decisions of small-scale fishers when selecting target species. The model is based on logistic regression analysis and probability functions, which allow me to estimate the probability of fishers selecting a particular species on every fishing trip, and to identify the variables involved in the decision-making process.

It is important to recall that only lobster and octopus have a closed season in Yucatán and their fishing seasons overlap from August to December. Access to other species is unrestricted throughout the year (see Chapter 2). Thus, I assumed that every day in this overlapping period the main decision is between these two species, since this involves a major changing in fishing gear (see Chapter 2). I also assumed that the decisions are based on economic motivations and constrained by environmental conditions. This chapter begins by describing the structure of the discrete choice model, followed by data application, results, and discussion. The analysis was performed both on the pooled data from the three ports and each one independently. At the end of the Chapter I discuss implications of aggregating the data.

5.2. Logistic choice model: what species to target?

Discrete choice models implicitly recognize the uncertain nature of the problem by predicting the probability of an individual choosing a given alternative or the probability that an event occurs ($P=1$) or not ($P=0$). Hence, the predictions are discrete outcomes as the dependent variable is binary (*1 or 0*). These models also help to identify the variables useful in making the selection derived from a set of variables that can be continuous, dichotomous or a mix of types. Thus, one can use the estimated probabilities to predict the proportion of each group of individuals that select an alternative (see Opaluch and Bockstael 1984; Gaertner *et al.* 1999).

Under this model, the occurrence of an event can be expressed as a probability, or a ratio of probability. However, as the dichotomous variable has restricted values, transformation of the logit probabilities (also called in the literature as 'odds logit') eliminates the possibility of obtaining estimations that exceed the maximum-minimum possible values. Hence, the probability can be estimated by the function (5.1) below (see Menard 1995; Tabachnick and Fidell 1996).

$$\text{Prob}\left(\frac{Y_j}{x_i}\right) = \frac{e^{T_i}}{1+e^{T_i}} \tag{5.1}$$

where:

$$T_i = a + \sum_{k=1}^{K} b_k X_i \tag{5.2}$$

T_j is the linear combination of the variables involved in the decision-making process, a and b_k are parameters of the logistic regression analysis (k=1, 2....n), and X_i are the predictors for the selection of species i.

In this study I define the dependent variable as the probability that fisher j chooses species i [$Y_j(X_i)$]. Hence, this probability takes the value of one for the selected species in each fishing trip. This model incorporates the assumption that small-scale fishers might try to maximize the benefits from their catch selecting the most profitable specie between two options. Because of its high price in the market, the selected species in this case would be lobster, hence it would get a probability of 1 and the other species take values equal to zero for a particular trip.

Once the parameters for T_j were estimated by the logistic regression, the membership of every case in any of the outputs was related to observations to estimate the probabilities based on the function (5.1). Predicted probabilities were expected to fall either close to zero or to one in order to assign a trip to one specie or another. In the cases where the predicted probability was equal to 0.5 (defined as the cutoff for classification in one category or another), the case was randomly allocated to either side of the binary variable. The predicted outcomes were compared with the actual outcomes using survey data from 1994. Later, validation of the model was performed with a larger data set coming from the same ports in an earlier fishing season (same used in previous analysis, i.e. 1992)

Logistic regression analysis has been used in ecology to define presence or absence of species in a particular area (Murtaugh 1988; Watson and Hillman 1997), but seldom in analysis of fisheries (Gaertner *et al.* 1999). Studies using this approach for the selection of target species in small-scale fisheries have not been reported.

5.3. Application to data

Information for this study was obtained from a survey data base provided by CINVESTAV from a large project to evaluate the small-scale fisheries in Yucatán. Initially 30% of fishers from each port were selected at random for the study. However not all of them were willing to accept an interview and keep a record of their daily activities after every fishing trip. Thus while all fishers from Sisal (one cooperative) participated, only 10% from San Felipe and Dzilam Bravo did so. The survey involved 43 fishers selected randomly from San Felipe (15) Dzilam Bravo (12), and Sisal (16). Participating fishers completed a form every day during August 1994. This period was used because the fishing seasons for lobster and octopus overlaps (see Chapter 2). The questionnaire was designed to record the daily activities of the individual fishers. The information gathered includes catch composition, expenses incurred on every trip, as well as personal information and environmental conditions as perceived by the fisher (see Chapter 1 and Appendix III.1).

A total of 756 daily trips with no missing data were analyzed. This total is made up of 319 cases from Sisal, 285 from San Felipe and 152 from Dzilam Bravo. Analysis was carried out using a merged data matrix including all fishers from the three ports as individual cases, and also for each port independently, testing the same hypotheses in both cases.

5.4. Hypotheses and variables selection

During the first interview, fishers generally said that their perception of resources abundance was their main consideration when selecting species. Variations in their catches define their expectations regarding changes in resource abundance. Thus, I define the perception of resource abundance in terms of catch expectation. Hence, taking into consideration fishers' perceptions and the literature, I assumed that the factors involved in the decision-making process of fishers when selecting a particular species are: economic, catch expectation based on perception of resource abundance, and climatic conditions. I tested the following related hypotheses regarding fishers' criteria to decide which species to target on a fishing trip:

1) random choice (RCH), which presumes that all the fishers make choices in a random way;

2) economic incentives (ECO), which presupposes that the choice is driven by economic factors and;

3) fishers' perception (FP), which considers the choices made from the fishers about resource abundance.

It is important to mention that the hypotheses proposed above are not independent. If the random choice hypothesis is accepted, the other two would be rejected by default. But, hypotheses 2 and 3 are linked because the revenues would come from the catch based on the abundance of the resources. I separated them into two hypotheses in order to analyze explicitly the perception of fishers, expressed in the personal interviews. This was also done to shed light on the highly controversy about the potential economic motivation of small-scale fishers. Additionally, in many analyses, economic variables are encapsulated in one concept, income or net revenues for instance (Lane 1988; Bockstael and Opaluch 1983). In this study, I separated cost and revenues to evaluate independently the contribution of each variable to the total revenues of fishing trips, and its influence in the decision-making process.

I tested the hypotheses in terms of the observed results of the logistic regression analysis expressed as the coefficients (b_k) in function (5.2):

Random selection

Ho: all coefficients= zero or not significantly different from zero;

Economic incentive

Hi_1: coefficients related to economic variables significantly different from zero;

Fishers' perception

Hi_2: coefficients related to catch per unit effort significantly different from zero;

If the null hypothesis is accepted, then the random selection is valid, and none of the other predictors is significant, which indicates a random selection of target species by fishers. If at least one of the economic variables is significant (Hi_2) the economic incentive criterion is valid. If catch per unit of effort is significant, the fishers' perception hypothesis (Hi_3) is accepted. However, acceptance of (Hi_2) does not mean rejection of (Hi_3). In all cases, it was assumed that uncertainty exists owing to constraints imposed by environmental conditions (W).

Numerical variables

Revenues from the previous trip (PR_L and PR_O) were considered as an indicator of the expected revenues. I assumed that the rational expectation of small-scale fishers relies mainly on the catch from their previous trips and the revenues derived from it. Auto-correlation of catch for each one of the species supports this assumption. A lag of one day was considered for this variable, as the coefficients were higher for the first lag than for subsequent ones, thus selection of one-day lag appears to be appropriate.

If the economic hypothesis was valid, a negative coefficient was expected for the previous revenues from octopus if the target was lobster, and a positive coefficient if the target was octopus. Total revenues obtained by the fisher *j* in each trip catching species *i* (TR_{ij}) were estimated by function (5.3). This includes the price of each species (P_i) times its $catch_i$. The sharing distribution of revenues among the crew is indicated by the denominator, where one is added for the maintenance of the boat (see Chapter 2 for explanation of sharing system in each port).

$$TR_{ij} = \frac{Pi * catch_i}{fishers + 1} \tag{5.3}$$

Travel costs (TC) include cost of fuel, oil and food. In the case of octopus, some fishers catch their own bait (crab) a day before fishing, while others buy it from other fishers. The cost per trip to get the bait or the price paid for it was included in the travel costs when specified. The opportunity cost of labor (OC), also defined as income for alternative employment, was considered in this case as the minimal wage per day in the region that year ($4/day). Thus, the equivalent for one hour was $0.50 US. This value was multiplied by the fishing time (hours) to estimate the opportunity cost. Revenues and costs were calculated in USD, based on the average exchange rate for that year (3.1 pesos/$1 US).

The catch per unit of effort of the species caught in previous trips (P*CPUE*) was used as an indicator of expected catch. Hence, to test the fishers' perception hypothesis, a lag of one day in this variable was used as reference. Other lags could be used as auto-correlation of revenues per trip for lobster and octopus were significant for other levels as can be noticed ahead. However the highest significance is reflected in the first lag. If lobster was the selected target, for this variable, positive coefficients of $PCPUE_L$ were expected.

Categorical variables

Weather (W) was the only categorical variable used in this analysis. This variable was defined with four levels according to conditions that can limit or favor the use of a particular gear. These were: *Rain*, *Ewind* (wind coming from the East), *Nwind* (wind coming from the North) and *calm* (good weather). The variable wind was divided into two categories because, according to the fishers, it is the wind direction that determines the method used to capture some species. Wind coming from the north can completely shut down fishing activity, while wind from the east appears to favor octopus catch, but makes the harvesting lobster more difficult (see Chapter 3). The indicator category (when a dummy variable is set at zero) was good weather. Table 5.1 shows the expected coefficients in the logistic regression analysis for each level of the categorical variable for weather.

Table 5. 1. Codification of categorical variable for weather with four levels. The expected sign in the logistic regression for each species is presented. IC is the indicator category.

	Good	*Rain (Wr)*	*Wind East (W_E)*	*Wind West (W_W)*
	0	1	0	0
Coding	0	0	1	0
	0	0	0	1
Expected coefficients				
If lobster	IC(0)	(-)	(-)	(-)
If octopus	IC(0)	(+)	(+)	(-)

Economic variables and resource abundance were considered as the only alternative hypotheses to define the hypothesis. However, some authors contend that other variables influence fishers' decisions in the short term when selecting target species (see Pálsson 1988; Hilborn and Ledbetter 1985; Healy and Morris 1992). Factors such as fishers' experience (E) and boat attributes (B) have been mentioned as important variables in the decision-making process. For example, fishing lobster involves diving and searching actively in extensive areas. A 'good' boat and good skills might make fishers feel more confident in selecting lobster as a target, even under climatic conditions that might seem risky

When testing the random hypothesis, I also added fishers' experience and boat size and engine power in the analysis. To test economic motivation I included all the variables used in the random test except catch per unit of effort (*CPUE*), because of multicollinearity (when predictors are correlated) with revenues. Finally, for the fishers' perception hypothesis, revenues were excluded for the same reason. Therefore, the variables (or predictors) used in this analysis and incorporated in function (5.2) are defined by the following function:

$$T_i=f(PCPUE_L, PCPUE_O, PR_L, PR_O, TC, OC, W, B, E) + \varepsilon_i \qquad (5.4)$$

Where: *PCPUE*= catch per unit effort from of one fisher in his previous trip, *PR*= revenues from the previous trip, *TC*= travel costs, *OC*= opportunity cost, *W*= weather, *B*= engine power, *E*= Fisher' experience (in years). Note that PCPUE and *PR* are specific for lobster (*L*) and octopus (*O*). The unit of effort in this case is fishing time in hours. ε_i is the error associated to the estimation.

The variables TC, PR_L, PR_O, and OC have an economic component, which can contribute to the net revenues for the fisher in every trip. Net revenue was not considered alone because it could overshadow the independent contribution of the variables comprised on it, and since information about other sources of income for the fishers in the area are not available. Hence, revenues refer only to the economic benefits derived from fishing.

Catch per unit of effort for lobster and octopus ($CPUE_L$ and $CPUE_O$) were considered as indices of abundance for each species. I adopted this assumption because of a lack of a better estimate and under the following premises: i) after the closed season for lobster and octopus these resources would be distributed more or less in a homogenous way, and ii) fishers have not swept out all the patches in the area. These assumptions could be relaxed in future research.

5.5. Model selection

To obtain the coefficients of equation (5.2), I performed the logistic regression using SPSS V. 9.9 software (Norusis 1993). Logistic regression is a special case of a General Linear Models (GLM) with a logit link function (see Hosmer and Leweshow 1989; Menard 1995). According to Tabachnick and Fidell (1996), these models make no assumptions about the distribution of the predictor variables, such as normality, equal variance, or the existence of a linear relationship. To select the significant variables in the model, I explored multiple tests applying stepwise, forward selection and backward elimination methods. As results were similar in all cases, I chose the backward likelihood ratio (BLR) procedure for the final analysis.

Since the model is not linear, its parameters need to be estimated using log-maximum likelihood, as criteria of goodness-of-fit (Norusis 1993; Tabachnnick and Fidell 1996). This is calculated through an iterative process based on summing the probabilities associated with the predicted (*Yi*) and actual outcomes for each case (yi), which yields values for the unknown parameters that maximize the probability of obtaining the observed data set.

$$\text{log}-likelihood = \sum_{i=1}^{n} y_j \ln(Y_j) + (1-y_j)\ln(1-Y_j) \quad (5.5)$$

Gaertner *et al.* (1999) emphasize the importance of the necessary tradeoff between under-fitting a model (too little structure with a large bias), and over-fitting it (too many parameters and large variance). Akaike's Information Criterion (AIC) in the likelihood context has been recommended for building statistical models emphasizing parsimony. The AIC index is estimated as:

$$AIC = (-2\,Loglikelihood) + 2k \quad (5.6)$$

where k= number of parameters in the model. The model with the smallest AIC was chosen as the parsimonious one. Since the likelihood value is a small number less than one, it is common to use –2 times the log of the likelihood (-2LL) as a measure of how well the estimated model fits the data.

I tested the level of significance of each coefficient when comparing alternative models though the Wald statistic test (Menard 1995). This test considers the coefficients (b_k) and the standard errors (SE_{bj}) associated to them.

$$W_j = \left[\frac{b_j}{SE_{b_j}}\right] \quad (5.7)$$

The Wald statistic has the disadvantage of overestimating the standard error for large b_k, which can result in failure to reject the null hypothesis when it is false. On the other hand, statistical significance of the intercept cannot be obtained by the log-likelihood estimate (Prager and Fabrizio 1990; Menard 1995). Therefore, I took all statistics (5.5 to 5.7) into account to select the final models.

5.5. Results

Table 5.2 shows the mean values of the predictors used in the analysis by port, and values for all merged ports. The highest revenues per trip from catching lobster were obtained in Sisal, which also showed low revenues from octopus. This coincides with high lobster catch per unit of effort ($CPUE_L$) and low for octopus ($CPUE_O$). Revenues in San Felipe and Dzilam Bravo were similar for lobster but not for octopus (Table 5.2). Although the coefficient of variation was similar in San Felipe for both species, a high coefficient of variation of revenues for octopus was observed in Sisal. This could be attributed to the low catch of this species in that period.

Table 5.2. Mean values and coefficient of variation (CV) of variables used in the logistic regression analysis.

Variable	*Sisal*		*San Felipe*		*D. Bravo*		*Merged*	
	Mean	*C.V. (%)*	*Mean*	*C.V (%)*	*Mean*	*C.V (%)*	*Mean*	*C.V (%)*
Fisher's experience (years)	7.1	19	8.7	17	15.9	26	9.1	41
Power engine (HP)	55.6	2	58.4	8	46.5	42	55.1	17
CPUE for lobster (kg/trip)	1.1	69	0.6	128	1.1	106	0.8	96
CPUE for octopus (kg/trip)	0.3	553	2.8	157	2.3	229	1.2	252
Revenues from lobster ($/trip)	59.7	68	33.8	126	30.7	114	44	97
Revenues from octopus ($/trip)	11.2	325	20.6	125	10.5	272	16.9	211
Travel costs ($/trip)	26.8	31	27.1	34	26.1	48	26.7	36
Opportunity costs ($/trip)	3.2	17	3.3	28	3.6	23	3.3	24

In all ports, mean values of travel cost and opportunity cost were similar. However, the coefficient of variation for travel cost was higher for Dzilam Bravo than elsewhere, even though average fishing time in the three ports was similar (between 6 and 7 hours). In San Felipe and Dzilam Bravo this time varied more among fishers, and in some cases for the same fisher in different trips, than it did in Sisal.

The use of revenues from the previous trip as an estimator of expected revenues seems reasonable when we look at the correlation between lobster revenues from one trip to the next. (Table 5.3). With a lag of one day, the correlation coefficients were much higher for lobster than for octopus (Figure 5.1).

Table 5.3 Auto-correlation for lobster and octopus revenues per trip. Standard error estimation based on Barlett's approximation P=0.05

Lag (day)	*Lobster*	*SE*	*Octopus*	*SE*
1	0.60	0.01	0.30	0.08
2	0.36	0.01	0.24	0.08
3	0.22	0.11	0.19	0.09

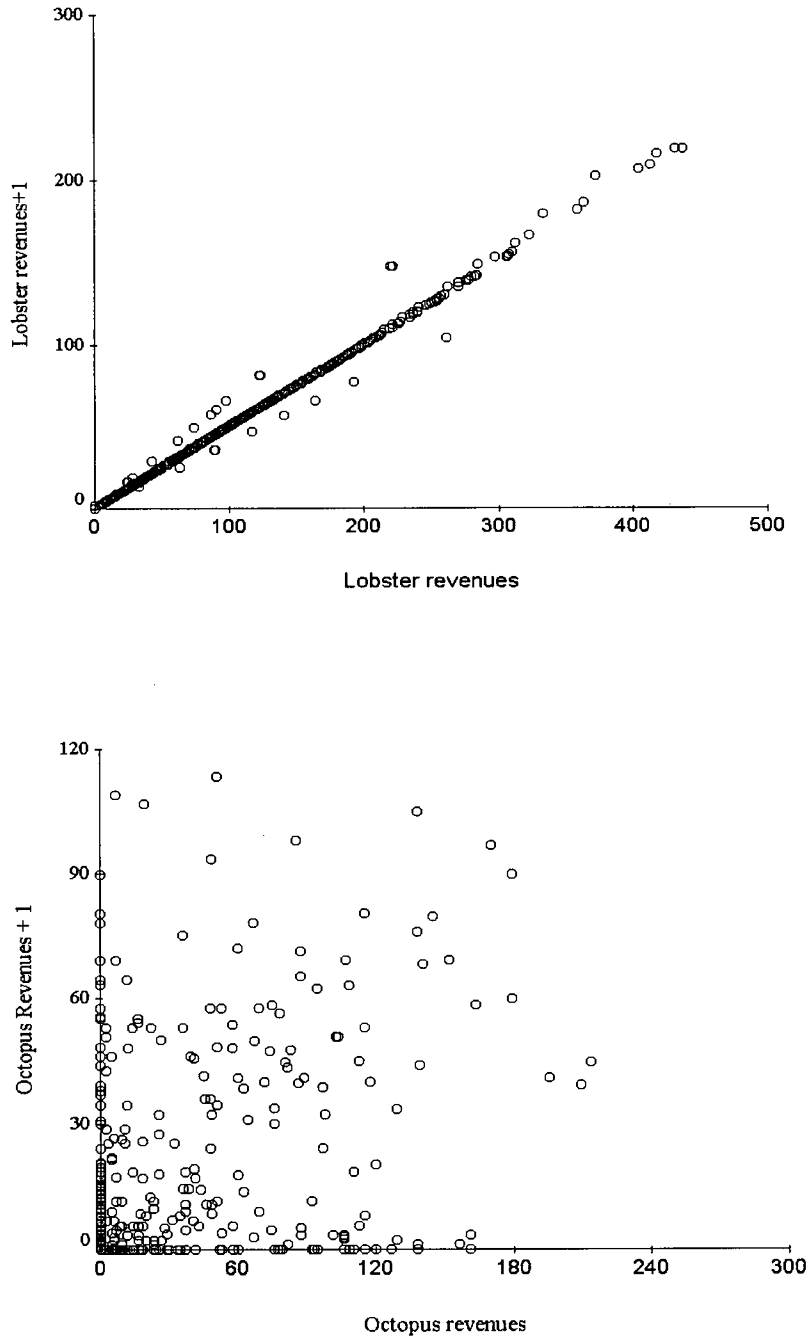

Figure 5.1 Auto-correlation of revenues per trip for octopus and lobster with a lag of one day. Fishers from all the ports are included.

5.6.1 Testing the hypotheses

Merging ports

Results from the logistic model for merged ports showed that the coefficients of five variables of the original 7 were different from zero. Therefore, the null hypothesis of random choice was rejected, i.e fishers do not behave randomly when selecting the target species. Parameters related to experience and boat characteristics were not significant, and were eliminated from all the subsequent analysis.

When the economic hypothesis was tested, previous revenues, travel costs, and opportunity costs were significant. Previous revenues from lobster were positive, while those from octopus, opportunity cost and rain for weather (Wr) had negative coefficients (Table 5.4)

Table 5.4. Estimated coefficients from economic hypothesis. Only significant variables are included.

Variables	*b*	*SE*	*Wald test*	*P*
Constant	0.91	0.44	4.31	0.036
Previous octopus revenues	-0.49	0.06	61.04	0.000
Previous lobster revenues	0.26	0.14	3.66	0.059
Weather (Wr)	-1.54	0.06	61.04	0.001
Travel costs	0.03	0.01	8.78	0.003
Opportunity costs	-0.22	0.12	3.66	0.050

Previous catch per unit of effort (*PCPUE*) was also significant for the fishers' perception hypothesis, with three significant variables in this analysis (Table 5.5). The results showed that weather is a significant variable with a negative effect on the targeting of lobster during rainy days. Positive values of the weather coefficients were obtained when the target species was octopus.

Table 5.5. Estimated coefficients from fishers' perception hypothesis. Only significant variables are included.

Variables	*b*	*SE*	*Wald test*	*P*
Constant	0.51	0.64	3.46	0.071
Previous octopus CPUE	-0.07	0.01	81.60	0.020
Travel costs	0.06	0.01	6.20	0.001
Weather (Wr)	-1.49	0.39	14.40	0.004

Regarding the variable related to weather, negative values of the coefficient for rain were associated with a decrease in the probability of fishers targeting lobster for both hypotheses. This makes sense because searching for lobster requires clear. In the case of octopus, wind is a benefit as the boat drifts with the wind giving more exposure of the bait to the prey. It has also been reported that high octopus catches are associated with windy days, except during the 'nortes' (Salas *et al.* 1991).

When targeting octopus was defined as the dependent variable instead of lobster, the results were the same, but with coefficients with opposite sign. Furthermore, the overall function that defines the probability of selecting lobster or octopus can be represented by the function (5.1) for the economic and fishers' perception hypotheses where T_i varies for every case as follows:

Economic

$$T_{lobster}= a-b_1(PR_o)-b_2(W_r)+b_3(TC)+\varepsilon_I \qquad (5.8)$$

$$T_{octopus}= a-b_1(PR_L)-b_2(W_r)+b_3(TC)+\varepsilon_I \qquad (5.9)$$

Fishers' perception

$$T_{lobster}= a-b_1(PCPUE_o) +b_2 (L_L)- b_3 (W_r)-b_4(TC)+ b_5(OC)+\varepsilon_I \qquad (5.10)$$

$$T_{octopus}= a+b_1(PCPUE_o)-b_2 (PCPUE_L)- b_3 (W_r)-b_4(TC)+ b_5(OC)+\varepsilon_I \qquad (5.11)$$

It is important to emphasize that the present models do not involve a nested process, that is when the probability of one event depends on the outcome of another. I assumed for this particular study a day-to-day process where fishers based their decisions on perception and expectations about the consequences that the outcome would bring, based on the information available, without considering other linked decisions; nested models could be used in an extension of this work.

5.6.2. Estimation of probabilities

From the results shown in Tables 5.4 and 5.5 and applying function 5.1, I estimated the probabilities of targeting each species and compared the observed cases with the predicted outcomes. It was observed that for fishers getting high returns from lobster in one trip, the probability of targeting the same species on the next trip scored high.

Figure 5.2 shows three examples of individual cases (selected randomly) from each port when the economic hypothesis was tested. The predicted group for targeting lobster [$P_j(X_i)$=1] and octopus [$P_j(X_i)$=0] was fairly accurate in general for these particular fishers. Fisher $\mathbf{Si_7}$ (from Sisal), for example, did target mainly octopus in each one of his 17 trips in August. In Dzilam Bravo, fisher $\mathbf{Db_{10}}$ targeted exclusively lobster, and all his trips were accurately predicted. In San Felipe, two cases were mis-classified for fisher $\mathbf{SF_{139}}$ because they were in the marginal value at the cutoff, i.e. $P_j(X_i)$=0.5.

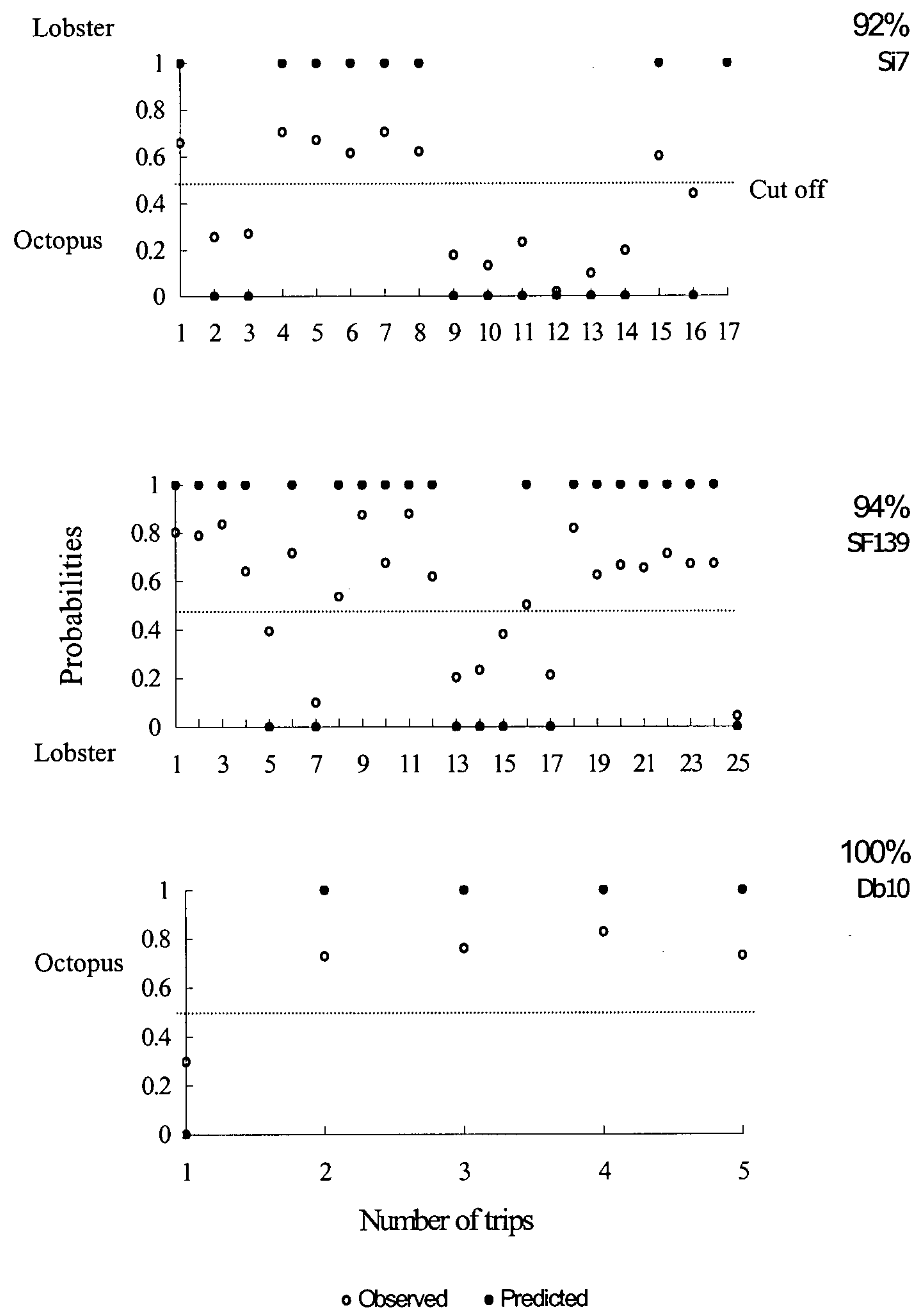

Figure 5.2. Predicted and expected values of choice model for individual case based on the economic hypothesis. One fisher per port is presented as example 1= probability for lobster; 0= probability for octopus. Individual ID and level of prediction at the right side.

The overall prediction was close to 75% from the 759 cases analyzed. A total of 183 cases (24%) were mis-classified with the fisher perception hypothesis, 575 cases were accurately predicted for lobster and 181 for octopus. With the model derived from the economic hypothesis 461 cases were correctly predicted. For example, some of the results including the three ports using as an example the fishers' perception hypothesis are shown in Figure 5.3. Observed values and predicted values (outcome from the model), indicate that more fishers targeted lobster than octopus during the analyzed period in all ports. Overall accuracy of prediction is high, even though some cases were miss-classified (thus at the level of the cut-off line). Since individual variation is to be expected (even the same fisher can take different decisions on different days), perfect predictions are not expected. If that was the case, this graph would show a clouds of dots close to each of the selected species with minimal number of cases or none near to the cutoff line.

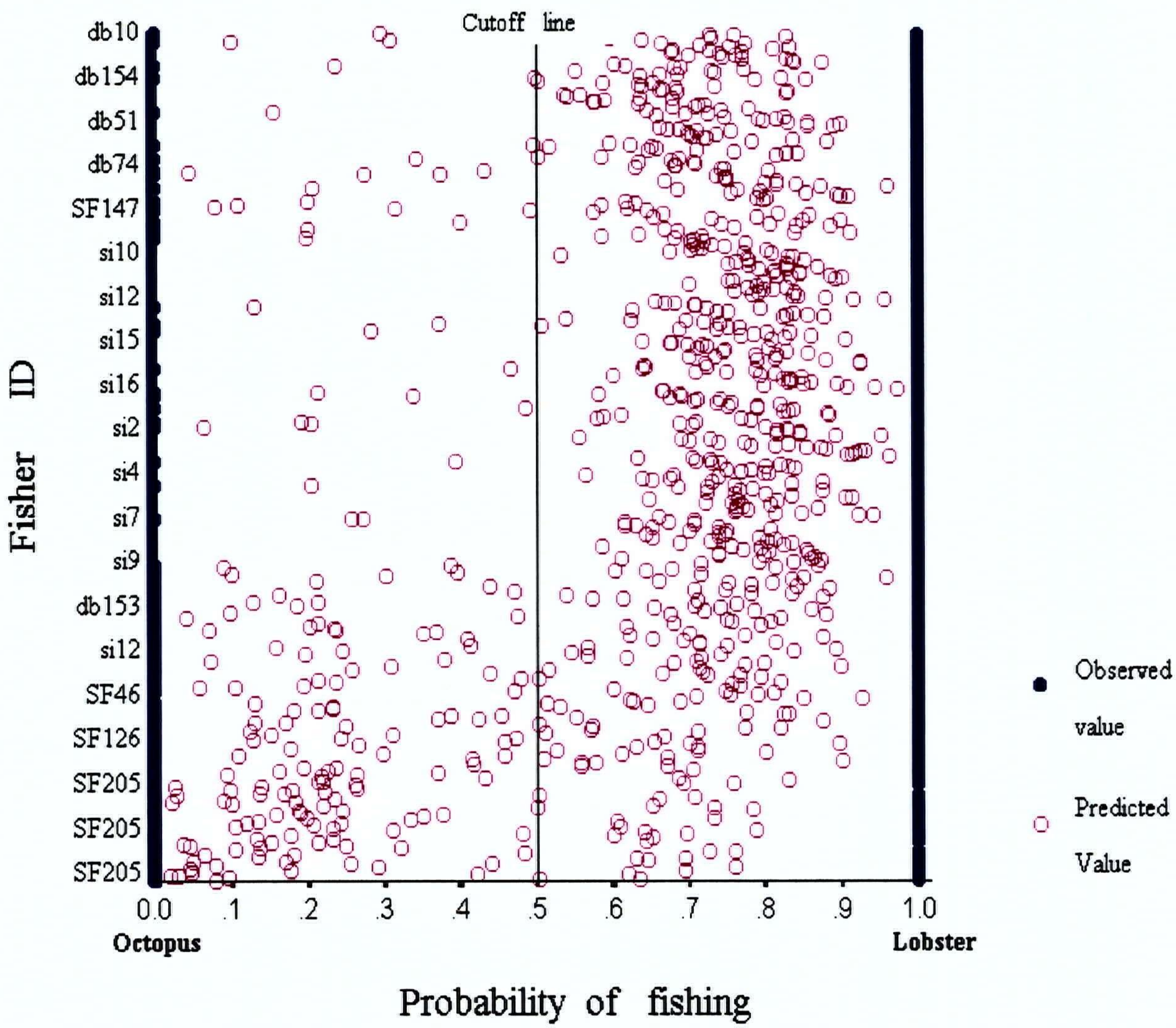

Figure 5.3. Expected and predicted values of probability of fishers catching lobster including all fishers. Given the difficult of displaying all cases in the vertical axis only 18 of the 43 fishers are shown.

The possibility of individual extreme cases influencing the performance of the model was explored using an analysis of the residuals (Menard 1995). From these, 20 'extreme cases' were eliminated, from which 12 corresponded to San Felipe. Elimination of these cases did not change the general results. Individual variation was also evident through the analysis of the residuals as the mean values for fishers from San Felipe varied more than for fishers from the other two ports.

Heterogeneity in the sample because of random variation or actual differences among the groups could produce some cases outside the range of the standardized residuals. This heterogeneity was confirmed by the mean deviance of the residuals, which shows identifiable clusters for each port (Figure 5.4).

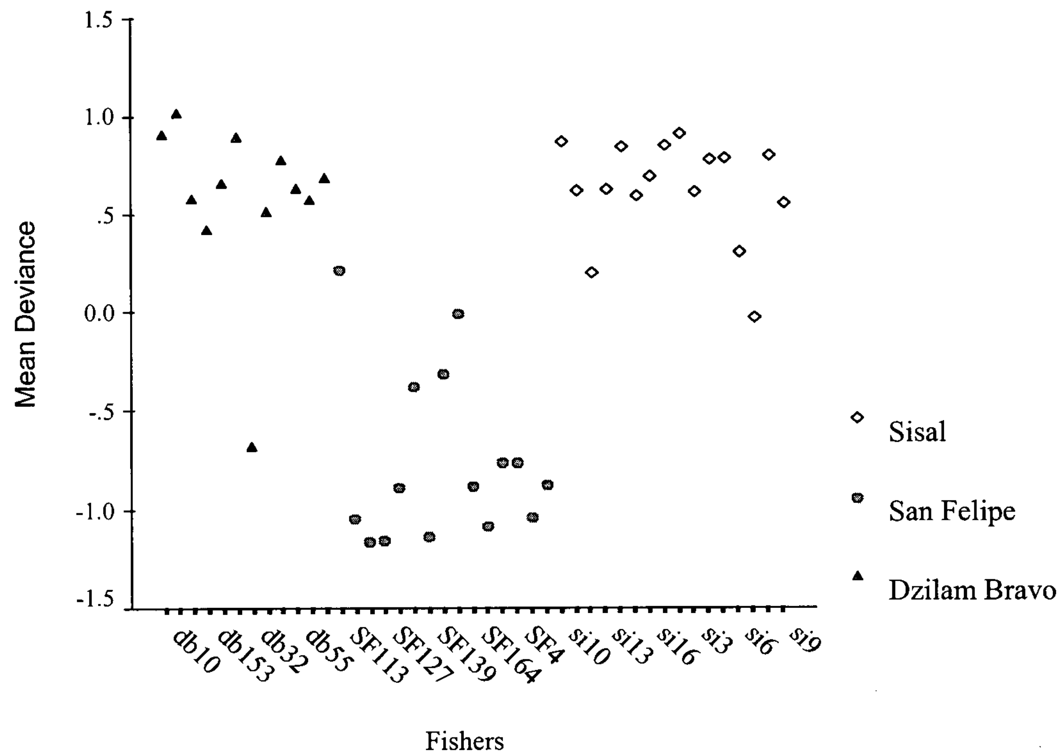

Figure 5.4. Mean value of deviance from the residuals derived from the logistic regression analysis.

Splitting ports

Results in Chapter 3 and 4 indicated heterogeneity of fishers both among and within ports. Among-port variation was confirmed in this analysis as well when the ports were merged for the analysis. Results in table 5.6 show that when the ports were analyzed separately for within ports variation, again the random choice hypothesis was rejected. For the economic hypothesis, previous catch of octopus was a significant variable (as in the overall analysis) for Sisal and Dzilam Bravo. Travel costs were significant for Sisal and Dzilam Bravo, but not for San Felipe, where the opportunity costs were significant instead. In this analysis, weather (E*wind*) was significant in Sisal and San Felipe, but not for Dzilam Bravo. In the case of the fishers' perception hypothesis, *PCPUE* from octopus was significant in all the ports, with a negative sign the same as that of travel costs. Weather (*Wr*) was significant for Sisal and San Felipe, but not for Dzilam Bravo. A summary of results from the analysis is presented in Appendix III.2.

Table 5.6. Estimated coefficients from the logistic regression splitting ports for economic (Eco) and fishers' perception (FP) hypotheses. Variables include: previous CPUE for lobster and octopus ($PCPUE_L$ and $PCPUE_O$), opportunity cost (*OC*), travel cost (*TC*), and weather for rain (*Wr*).

	Sisal		*San Felipe*		*Dzilam Bravo*	
Variables	*Eco*	*FP*	*Eco*	*FP*	*Eco*	*FP*
Constant	1.20	1.17	0.06	1.17	-3.93	-0.28
Previous octopus revenues	-0.08				-0.07	
Previous octopus CPUE		-0.21		-0.16		
Previous lobster CPUE		0.14		0.40		-2.21
Opportunity costs			-0.6	-0.10	0.89	
Travel costs	0.08	0.08			0.15	-0.21
Weather (Rain)	-1.95	1.08	-1.05	-1.10		

The equations for each port, presented below, gave a higher accuracy for each port when compared with the overall model (merging all ports). Nevertheless, San Felipe still shows a lower level of prediction (80%) regarding the other two ports: 82% for Sisal and 88% for Dzilam Bravo. The level of prediction was equal for both hypotheses (economic and fisher perception), although the resulting functions are different for San Felipe and Dzilam Bravo. The functions for lobster are presented:

Sisal

Economic $T = a\text{-}b_1(PR_o)\text{-}b_2\ (w_R)+b_3(TC)+\ \varepsilon_I$

Fisher perception $T = a\text{-}b_1(PCPUE_O)+\ b_2(PCPUE_L\ )\ +b_3\ (w_R)+b_4(TC)+\ \varepsilon_I$

San Felipe

Economic $T = a\text{-}b_1\ (w_R)+b_2(oc)+\varepsilon_I$

Fisher perception $T =\ a\text{-}b_1(PCPUE_O)+\ b_2(PCPUE_L)\ -b_3\ (w_R)\text{-}b_4(OC)+\ \varepsilon_I$

Dzilam Bravo

Economic $T = -a - b_1(PR_o) + b_2\ (TC) + b_3(OC) + \varepsilon_1$

Fisher perception $T = -a - b_1\ (TC) - b_1(PCPUE_O) + \varepsilon_1$

The effect of opportunity cost turned out to be significant in San Felipe and Dzilam Bravo, but not in Sisal. From additional data from the interviews, it was reported that only fishers from Dzilam Bravo acknowledged having alternative jobs, such as being a tourist guide. In Sisal, one of the fishers was a musician, but does not consider this activity an alternative source of employment. In San Felipe, however about 15% of the fishers recognized alternative sources of income such as work in construction, cattle ranching, husbandry, or farming. Fishers from this port also have access to loans from the cooperative in case they need them. Some of the fishers mentioned that if the season is 'not good' they can borrow money from the co-operative. Relying on access to the benefits obtained from the co-operative was a common perception of fishers from this port.

5.6.3. Testing the models on a different data set

To validate the models (merged and split) I used the daily catch data from 1992 (the same data as the used in chapters 3 and 4). The data set includes daily catch by species and fisher during August. For this data set I did not have daily travel costs per trip, hence I used monthly average travel costs by trip. Opportunity cost was considered as the minimum wage in that year. I tested the model with 4970 trips including a total of 377 fishers from the three ports.

The level of prediction in testing the pooled models was 60% for the economic hypothesis and 70% for the fishers' perception hypothesis (Table 5.6). For separate analysis of the ports, predictions were accurate in appropriately 70% of the cases. In San Felipe, more cases were miss-classified than in Dzilam Bravo and Sisal. The overall predictions can be considered good given the large data set used to validate the models. Differences in these data set compared with the one with which the model was constructed were expected owing to several factors, including the fact that average values of travel costs were used instead of daily data, as well as the inherent variability in a larger data set. According to Menard (1995), this low level of prediction does not necessarily indicate a problem with the model, as one is dealing with a non-deterministic process in which individual choice and free will naturally produce a less than a perfect prediction of human behavior.

Table 5. 7. Level of prediction (%) of economic and fisher perception hypotheses. Models for each port and for merged ports.

Case	*Fisher perception*	*Economic hypothesis*
Sisal	72	70
San Felipe	60	65
Dzilam Bravo	68	65
Merged ports	70	60

Given the results presented (merged versus separated), one can wonder how many potential models could be produced with this type of analysis, and how appropriate they are for the questions addressed in this study. It is evident that results of the hypotheses tested lead in the same direction, because, abundance of the resources defines how much fishers can catch, and consequently how much they can earn. These results were confirmed also by information obtained from the survey. For instance, the questionnaire included open questions regarding factors that fishers considered when selecting target species and the fishing grounds. In all cases, abundance of the species and access under the regulations were reported as the main considerations. Fishers perceived changes in species abundance according to changes in both their own from previous days, and the catch from other fishers. From the fishers that were interviewed, about 80% mentioned this as the main consideration determining which species to target. The weather was an additional factor mentioned by many, while market demand was mentioned only by a couple of fishers. Random selection was mentioned by only one fisher. Even though the results of my empirical analysis show economic variables to be significant, fishers rarely mention them, so the underlying question is, why did the fishers not openly acknowledge the importance of economic variables?

In Yucatán, lobster price does not usually change within a season, as it is defined at the beginning of the season between the middle man and the co-operative Prices can vary for the other species throughout the year (see Chapter 2). In these fisheries, demand is defined by the main buyer, rather than by the free market. In the period that the study took place, slight changes were observed for octopus, but not on a daily basis. Hence, changes in prices in this period do not necessary influence fishers' directly on a daily basis. However, overall differences in prices between lobster and octopus can result in significant differences in revenue for every fishing trip, and finally, for the fishing season overall. In addition, some fishers report that increases in octopus abundance can reduce the abundance of lobster, as the former preys on the latter. Hence, given that fishing octopus requires less skill and time searching, fishers could try to make up for the lower prices of octopus by catching higher volume than spending more time and gasoline searching for lobster when they are less abundant. Therefore, the economic motivation, although not explicitly expressed, appears to influence fishers' behavior.

5.6.4. Predictions

In order to evaluate responses of fishers to changes in revenue or abundance of the resources, I used the obtained models to predict shifts in the target species by fishers. To test the economic effect, I simulated changes equivalent to a 3-fold increase in octopus price, equivalent to the one that took place in 1996 in Yucatán with no changes in lobster price. Results indicate that high revenues from catching octopus in previous trips decreased the probability of selecting lobster in the next trip. Similarly, increments in CPUE for octopus reduces the probability of targeting lobster in the following trips (Figures 5a and b).

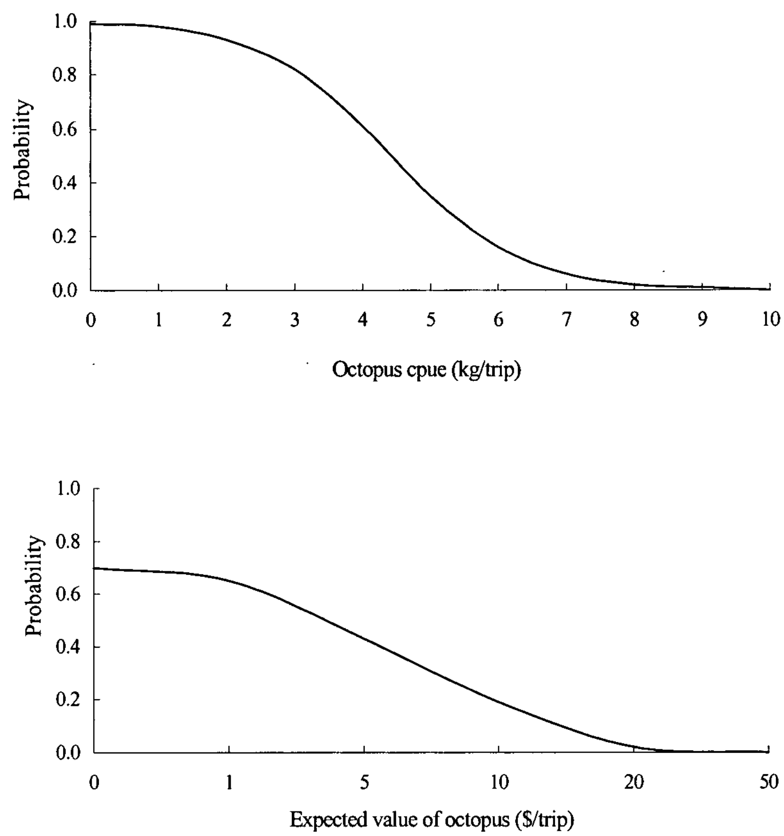

Figure 5.5. a) Changes in the probability of targeting lobster when expected value of octopus increases. b) Changes in the probability of targeting lobster given an increment in *CPUE* of octopus.

When octopus was caught in Dzilam Bravo, no lobster was reported. This clear division is not evident in San Felipe, where there seems to be a switch between both resources throughout the month. The fishing season for lobster starts one month earlier (July) than for octopus, and fishers seem to concentrate exclusively on this resource in Dzilam Bravo and Sisal before octopus becomes more accessible (September-October). Thus, octopus, although lower in price, provides high net revenues because of high catches and the low cost of operation given the type of fishing method, because once the fisher arrives to the fishing ground the boats is left drifting while fishing. Targeting lobster, on the other side demands more consume of gasoline while searching for the animals. The samples used for my analysis unfortunately do not cover this period. Applying similar analyses to other periods of the year would help to confirm the results presented in this study and help to provide better understanding of fishers' strategies.

5.7. Discussion and conclusions

In this section of the thesis, I used a choice model to predict the probability of fishers selecting alternative species, providing information about the variables involved in target decisions. The results indicate that this process is not random. Economic factors and resource abundance constrained by environmental factors play an important role in the selection process. With the type of analysis performed here, no algorithm would result in a 'perfect model', especially when we are dealing with human decisions (Menard 1995).

I do not claim that resource abundance and economic incentives are the only factors that influence fishers decision-making when selecting target species. However the information generated in this study can provide insights that can help us to understand fishers' dynamics. Other factors that were not included in the present analysis could also account for elements of fishers' behavior (McCay *et al.* 1989; McGoodwin 1991). Being a good diver, as opposed to being a recently displaced peasant, may influence the decision to catch lobster (even when not everybody does). Experienced fishers may be willing to take more risks in searching for the most profitable resource than non-skilful fishers (see Cabrera and Defeo 1997).

Analysis by individual ports, which shows the heterogeneity of fishers among the ports, improved the accuracy of prediction. Even though pooled model may fit for each particular port, there is no assurance that the same model would perform as well for other ports in Yucatán. Hence one must be cautious when interpreting the results from this analysis in a wider context. Despite these limitations, my work provides some insights into the day-to-day individual decision-making process of small-scale fishers when they are selecting target species. This approach could also be applied to problems similar to those mentioned above, such as nested processes in fishers daily decisions, such as selection of fishing grounds, or choices of alternative activities besides fishing.

There is clearly a fundamental complexity in trying to understand how fishers make decisions in one process that happens to be connected to others (Andersen 1982; Bockstael *et al.* 1989). In this particular case, I concentrated on the selection of target species, but before that, every day fishers have to decide if they will go fishing or do something else. The technicians who carried out the interviews observed that fishers from Sisal never fished on Sundays and Mondays, which are referred as 'party and recovery days respectively' (D. Blanqueto pers.comm.) In Dzilam Bravo on the other hand, time reserved to maintain the equipment, health problems and working in alternative activities were mentioned by fishers as reasons that prevented them from fishing. Only in a few cases, fishers explained their reasons for abstention by 'feeling like not going fishing'. The access to alternative opportunities appears to be very important in this decision, as some fishers are unable to make an adequate living from fishing alone and have to do something else.

The perception of alternative sources of income as well as the learning process, play an important role in fishers' choices (Pauly and Agüero 1992; Davis and Thiessen 1986). In this case using the minimum wage as an opportunity cost may not reflect the effect of a 'real' income alternative given the inflation problem in México that might make this cost negligible when translated to dollars. Evaluation of alternative activities and potential income could provide elements to expand and relax some of the assumptions made in the present analysis. For example, fishers can provide very valuable information to incorporate into this type of analysis. Sarda and Maynou (1998) emphasize that interaction between the fisher and the resource is evidently reflected in the specific behavior of fishers. They state that fisher's observations in research could provide insights to understand and manage fisheries, since throughout time fishers gather large amounts of information on the functioning of ecosystems and their resources.

Summary

In this Chapter, I used a logistic discrete model to test linked hypotheses related to the factors that define fishers' selection of target species. Independent hypotheses (economic and fishers' perception) showed consistent results leading to similar predictions: high catches of one particular species in one trip will define the selected specie for the next trip. Fishers appear to respond to changes in abundance of the resources, which are also reflected in their catches and consequently their revenues. Of the 759.

observations from the three ports, 70% of them were correctly allocated by the predictive models. Although the analysis would be simplified considering only one of the hypotheses, separating them can help to understand some of the different points of view presented in the literature, and also to incorporate the perception of the fishers in this type of analysis. Splitting the analysis by ports improved the level of prediction with the same variables showing significance, which shows the heterogeneity of fishers among the ports and support the results of previous analyses

CHAPTER 6

Fishing strategies of small-scale fishers and implications for management

6.1. Introduction

Hart and Pitcher (1998) state that conflicts among fishers and fishery managers can be reduced if managers can adjust their cost-benefit functions to achieve management objectives that consider fishers' interests, and acknowledge their dynamic behavior. Accordingly, Hilborn (1985) states that some fisheries have collapsed because managers do not account for the dynamics of the fishers, rather than because of lack of understanding of biological processes.

Conflicting demands can arise in the development of management plans, as fisheries managers often have to deal with allocation of scarce resources among diverse user groups, each with its own preferences. However, one problem is the common tendency to define programs that are expected to suit all fishers the same way. There is a failure to realize that fishers are not 'fixed' components in the fisheries system; diverse responses can stem from individuals within the same environment. Nevertheless, individual variation in the fishing patterns is seldom considered.

Uncertainty forms part of the 'fisheries environment', which is faced by fishers and managers alike. Fishers are uncertain of resource availability, market constraints, fisheries regulations, and environmental constraints; managers face it over fishers' response to regulations and with the political context. Different aspects must be considered as the system comprises different pieces, all of them important in the dynamic process. In this regard, my intention is to describe some of the pieces of this complex system. In the present study, I focused on fishing operations of small-scale fishers (short term) more than on the fishing units (long term). I would expect that the knowledge stemming from the former could contribute to a better understanding of the latter. My contention is that while fleet production still remains the central focus of research for management purposes, changes at this level can be seen with less potential bias by understanding the adaptive strategies of individual fishers in the short term.

In this section, I first summarize the results of previous chapters and discuss the relevance of the fishing strategies identified in the Yucatán context. I also review the current regulations in the area and propose some modifications based on my results. Next, I illustrate with a hypothetical example how fishers' strategies could be incorporated into the design of management schemes of small-scale fisheries by means of a conceptual management framework. Finally, I state the general conclusions from my study.

6.2. Fishers' goals, strategies and management

Table 6.1 summarizes the fishing strategies identified in my study. I also include what I consider to be the potential goals that capture the motivations of fishers in the definition of such strategies. In this section, I discuss what fishers' goals are; *what* factors constrain or motivate their activities; *how* they deal with such factors; and *how* this can be related to fisheries management. To support my arguments, I use my case study as a reference, as well as examples of small-scale fisheries in other regions.

Table 6.1. Fishing strategies in Yucatán and fishers' goals, their responses to different driving factors, and regulations. Technological control does not necessarily involve sophisticated modification to the fleet, but any aid that may increase the catching power of the boats. TFR stands for territorial fishing rights and MPAs for Marine Protected Areas.

Fishers goals	*Strategy identified in Yucatán*	*Induced by*	*Fishers' response*	*Current regulation*	*Proposed modifications*
Maximize or increase catch	Improving fishing efficiency	Economic factors Resource abundance Regulation	Increasing number of trips Changing boats attributes Acquiring new skills	Closed season, Entry boat control	Definition of TFR Control of number of boats and fishers Control technology
Maintain 'average' catch	Switching target species	Economic factors Resource abundance Weather, Regulation	Increasing number of trips Shifting gear and Species	Gear control Closed season	Closed seasons Gear control Elimination or re-direction of subsidies, Implementation of MPAs
Reduce Uncertainty	Working in cooperation teams	Weather conditions	Sharing catches and/or information	Not applicable	Not possible to control, but acknowledge its existence

6.2.1 Maximization of the catch

There is debate regarding the concept of fishers as profit maximizers. The assumption that fishers' response to high catches is motivated by economic incentives has been questioned in the case of small-scale fisheries (see McGoodwin 1990). This may be related to confusion between small-scale fisheries and subsistence fisheries. Agüero (1992) reports that in many cases in Latin America small-scale fishers focus their attention on 'fine' species, which are mainly for export (e.g. lobster, conch, abalone, etc.), providing an important source of foreign exchange. However, given the importance of small-scale fisheries to the national welfare in some countries, including México, they are perceived by governments mainly as a source of employment and food for people in the coastal regions and surrounding areas.

From my studies and experience working in the Yucatán coast, I contend that small-scale fisheries in that region do not fish only for subsistence. On the contrary, many fishers perform a commercial activity that, despite their low technological level, aims to generate high income if possible through large catches. Maximization of catch or profits may be pursued by some individual fishers, as in Dzilam Bravo. However, although a fisher would like to maximize his profits, the essential distinction between large and small scale fisheries is that small-scale fishers do not appear to be seeking capital accumulation. This distinction is evident by the strong dependency on the middleman for financial support. This appears to be the case for most small-scale fisheries (McGoodwin 1990).

I do not claim that all small-scale fishers will tend to maximize their catches if given the opportunity to do so. Actually, fishers from Sisal in this study appear to be a good example of the contrary. Dzilam Bravo, on the other hand, presents an interesting case that demonstrates the importance of understanding fishing strategies and maximization of catches and revenues. In this port, a wide range in the catch rates among fishers was observed. More efficient fishers in this port used larger boats, worked in cooperation teams, and make a greater number of trips throughout the year compared with fishers from other ports. Moreover, the most efficient fishers from Dzilam Bravo markedly exceed the catches of the majority. These elements were unknown and were not considered when more boats were allowed access to the fisheries in that area in 1994 (Figure 6.1).

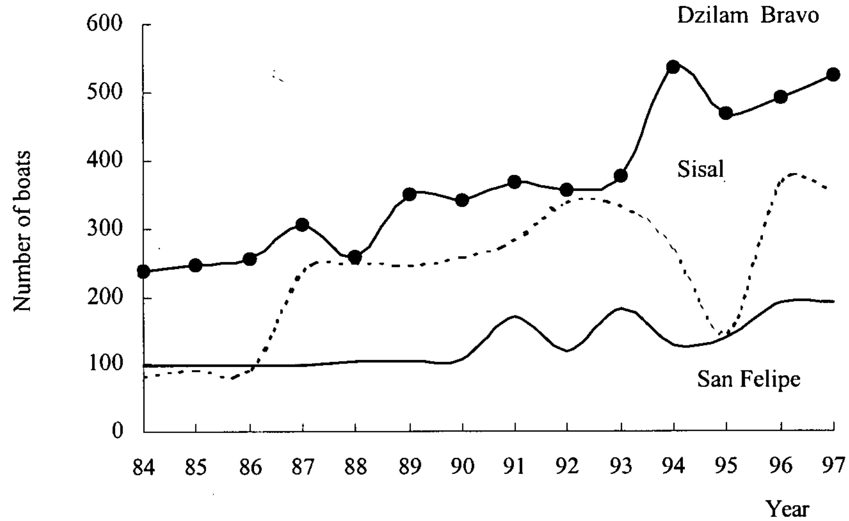

Figure 6.1. Changes in fleet size of the small-scale fisheries from 1984 to 1997 in Yucatán (includes registered boats).

Similar actions in the future could result in an increase in the effective fishing effort and reduction in the catch rate. This effect was observed in Dzilam Bravo from 1992 to 1993 when CPUE decreased about 30% after an increase of almost 40% in the number of trips.

In Yucatán, as in many other small-scale fisheries, regulation has been based primarily on input control, mainly by limiting the number of boats and closing the season for some species. The current regulatory system has not totally succeeded in controlling effort. Poor records of the number of boats (and their attributes) operating in each port and fishery, coupled with high mobility of fishers, makes it difficult to control access to each fishery in such a fashion. Additionally, fishers do not totally comply with closed seasons, which apply only to octopus and lobster. Every year several fishers have been caught with lobster out of the fishing season. I was also able to confirm that some fishers caught octopus during its closed season in one of the ports because they registered the catch in their logbooks.

Regardless of the high fishing pressure on two of the most important resources in this region, grouper and octopus, government programs have encouraged the development of other fisheries like lobster (see Torres and Salas 1993). Additionally, new licenses allowing entry of more boats have been issued (Informe de Gobierno en Yucatán 1999), contradicting the Federal Law of Investment (FLI) which states that no new licenses should be authorized after 1996 (Semarnap 1999). For example, in Dzilam Bravo more boats were allowed to enter the grouper fishery. This is contradictory with the attempts of introducing a partial closure for this fishery, which has faced strong opposition from fishers limiting its implementation. If managers continue to consider that managing the number of boats is the only relevant component of fishing effort, the real effect of fishing pressure can be misleading.

The analysis undertaken here shows that the number of trips was the most significant variable in the variation of catch and landed value. Controlling the number of trips is not easy given the difficulty of describing fishing effort by a specific fishery. However, a closed season can restrict access to some species and limit in some way the number of trips, as most of the fishers operate on daily basis. Yet, fishers may respond to modifications to closed seasons by working longer hours in every fishing trip or by spending more days fishing in a given month; they may even violate the regulations. Nevertheless, a combination of different regulatory measures that consider key factors in the definition of fishing efficiency could help to improve the management of these fisheries. Additionally, if the closed seasons are maintained, it is important to make revisions to define the convenience of retaining the length and the time of the closure. This has not happened in the past, for example, no changes have been made to the length of the closure for lobster in the past decade.

Given the conditions presented above, I recommend controlling access by area and time closures restricting the number of boats and number of fishers. It is also important to keep track of the sector in which fishers participate (i.e. social organization, private sector, or 'free-lance') and to monitor how many people take part in each activity. This is not an easy task, given the high mobility of fishers over an extended coastal region and the continuous incorporation of migrants from rural areas. However, it is necessary to make use of whatever information is available, including that provided by fishing organizations. In the database provided by the cooperatives that I used for my study, approximately 30% of fishers in two of the ports analyzed were not officially registered. Availability of this kind of information is the exception rather than the rule, but could still be a good source of information to complement surveys and regular statistics.

Regulations mentioned above could facilitate enforcement in places where territorial fishing rights (TFR) exist. This kind of 'sea tenure' has emerged as a way to prevent the effect of open access and to improve the welfare of local communities. Conditions such as low mobility of species, high cohesion among fishers permit relative defense of exclusive rights.

Territorial rights already exist in some parts of the Yucatán coast (as special concessions for lobster) and this approach appears to be possible in the region. People from the cooperatives involved have delineated its area of boundaries well defined. Territorial rights become more difficult to monitor when dealing with more mobile resources; however in some ports with a high level of organization and cohesion as in San Felipe, local control appears to operate efficiently. Murphy and Magaña (1983) noted that fishers from that port welcomed outsiders who would like to join the fisheries; however this situation does not appear to exist currently. Increased competition and growth of the fishing population has changed the conditions and arrangements of the fishing organizations, leading to more control and restrictions on access to limited resources, especially for valuable species such as lobster.

6.2.2 Maintaining average catch

Maintaining an average catch appears to be of common interest to fishers in all ports. Factors inducing this behavior, besides regulations and environmental conditions that impose constraints in fisher activities, are related to economic incentives, such as to obtaining revenues, at least equivalent to the costs incurred on their trips. Internal regulations of the fishing organization appear to be relevant in this regard as well. For example, to maintain membership in the cooperative, fishers in San Felipe are required to land 300 kg as the minimum average monthly catch (T. Castro per. comm.). Similarly, Roy (1998) reports that the Canadian Insurance Plan can modify the length of the fishing season of inshore fishers in Newfoundland. The program was established in order to enable the government to insure employees against the consequences of job loss. This program does not apply to self-employed people, but provides benefits for the fishers during the off-season in amounts dependent on their earnings during their fishing season. Thus, the fishers may define a target catch by adjusting the number of weeks that allow them to qualify for the payment.

Seasonal variation of species and regulation impose constraints on fishers. Thus, in order to maintain their income and their livelihood under uncertain environmental conditions, fishers could acquire skills to operate diverse types of gear that enable them to catch alternative species. Switching between target species during the season can be seen as a diversification plan to deal with seasonal variation of the resources and to comply with regulations. This diversification can help fishers to maintain a target catch sufficient to remain fishing, likewise this strategy has been referred as means to maximize catch (Opaluch and Bockstael. 1984). This switching behavior among alternative fisheries has been reported in the majority of small-scale fisheries described in the literature (see Panayatou 1982; Lawson and Robinson 1983; Yater 1982; Woznitzia 1992; Knudsen 1995).

Results from my choice model used to analyze switching behavior show that economic motivation and fishers' perception of resource abundance and environmental conditions play an important role in the decision process of selecting target species. These factors do not alone influence short-term fishers' decisions; other factors may also influence their behavior. For instance, fishers with good diving abilities, as opposed to recently displaced farmers from rural areas, may choose to target lobster instead of octopus under particular environmental conditions. Fishers with a longer tradition in this fishery are more willing than unskilled fishers to take greater risks in searching for the most profitable resource under 'bad weather' conditions. Fraga (1992), states that most of the rural migrants acknowledge that they are moving to a completely different environment and they generally try to adjust to the new conditions by selecting those activities that require fewer skills, such as fishing octopus or gathering bivalve mollusks.

The perception of fishers about resource abundance and potential non-fishing activities as an alternative source of income play an important role in their decisions. This appears to influence the mobility of fishers between species, gears, or even to other economic activities. Fishers' expectations and decisions based on their perceptions about potential benefits can change through time; a decision that initially was to be based on maintaining an average catch may turn into a strategy to increase catch as a result of economic stimulus. This appears to be the situation in the case of octopus in the last couple of years in Yucatán (see Chapter 2 and Chapter 5).

Under these conditions, how can one deal with fishers' perceptions? It is evidently difficult to define management instruments that change fishers' perceptions about how much is available for them to take from the sea. Although it is widely accepted that fishers have a good knowledge of the resources they exploit (Forman 1967; Ruddle 1994), it is also acknowledged that they may sometimes continue fishing before accepting that the stock has been affected by their actions. In the long term, this is reflected in the revenues of most of the fishers, including those that are considered successful fishers. In this sense, implementation of management areas such as Marine Protected Areas (MPAs) could contribute to influencing fishers' perception. These areas could be considered as an insurance plan in the long-term, acting as a refuge for one fraction of the exploited population. Replenishing nearby harvested areas could result in benefits in the future (Dugan and Davis 1993; King and Faasili 1998). Some initiatives of this nature have been promoted in some coastal areas where small-scale fishers operate (see Vincent and Pajaro 1997; King and Faasili 1998; Pet-Saede and Erdman 1998), yet only a few have succeeded.

Many shortcomings have to be faced in trying to implement MPAs in coastal regions. Enforcement is a big problem, but limited alternatives in non-fishing activities that provide income to small-scale fishers seem to be the main limiting factor in making them feasible (see Dugan and Davis 1993).

The benefits of protected areas have usually been stated in biological terms (Guénette *et al.* 1998); economic criteria to define 'optimum size' have been suggested as well (Sumaila 1998). However, the social and economic consequences of closing an area have become the main reasons for unsuccessful implementation of MPAs, especially in developing countries (see Erdmann and Pet-Soede 1996*)*. For example, in the coral reef fishery in Sperdmon archipelago, Indonesia, fishers seem to target almost all the resources available. Blast fishing, although strictly illegal, is a common practice in the area. Electroshock fishing to stun large schools of small fishes, such as clupeids and atherinids, is also common, as are bamboo traps to catch fish on the falling tide. Lack of alternative sources of income and the economic reward of these fisheries continue to attract more people (Erdmann, 1995). Erdmann and Pet-Soede (1996) state that although implementation of a protected area to prevent degradation of these fisheries has been proposed, the chances of making it a reality are remote. Overfishing is epidemic, regulation is sporadic, and indeed the only negligible form of regulation involves charging fees for the use of explosives. As these fees are still affordable, and given the profitability of the activity, fishers do not feel forced to change their fishing methods.

Community participation in the definition of the size and location of the MPA and rules of enforcement supported by technical and scientific advice are necessary to encourage fishers to take part in this type of program (Pomeroy and Williams 1996; Jentoft and McCay 1995; Vincent and Pajaro 1997). In some cases, the initiatives could be coming from the community. For example, fishing villagers in Samoa chose to establish a marine protected area in part of their traditional fishing zone. The community took this initiative under a fisheries extension program. Fishing in the area was banned, monitoring and enforcement was promoted for the same villagers (King and Faasili 1998). Another successful case of establishing a protected area exists in the Philippines, where a sanctuary to protect seahorses was defined in Barangay waters in 1995. No fishing in the area is allowed and compliance is high, thanks to the cooperation of voluntary patrols several nights a week and the support from the municipality. Fishers and biologists are cooperating on a series of surveys to detect changes in the abundance of seahorses. The high dependence of Handumon on seahorses has encouraged fishers to cooperate (Vincent and Pajaro 1997). Although in Yucatán some reserves have been implemented in the coastal area, there does not exist a no-take zone where fishing is banned. However, in San Felipe, Yucatán, some fishers have suggested the establishment of a marine protected area to protect lobster (R. Torres per. comm.). Up to now, the zone has not yet been defined, but the potential for this type of initiative exists. This is not the case in all ports; on the west coast, participation in and acceptance of this type of project is less common.

On the other hand, a common action in coastal areas has been to assist fishers in obtaining loans and to support the fishing activity through subsidies (Stennblik and Munro 1998); Yucatán is no exception (Salas and Torres 1997; Cabrera 1997), for instance, subsidies can change the perspective of fishers in terms of labor and capital investment. In small-scale fisheries, where small investments are required, reduction of costs can be an incentive to enter or remain in a fishery regardless of evident reduction in catches. Fishers need to recognize the real costs of their activities. In this sense, elimination or re-direction of governments' support to the community could be of more benefit to the whole fishery than only for some individuals. This intervention could affect the activity in a way that allows fishers to recognize the real costs incurred in their operations.

Steenblink and Munro (1998) state that better fisheries management involves more than limiting production. They stress that it also involves dealing with chronic structural imbalances in the sector to which government has contributed to by financial transfer management (for example subsidies), preventing adjustment between capacity and fishing production. Subsidies added to lack of input-output control have contributed to unsustainable management and overcapacity, which does not involve only conventional capital, but human capital as well. Unfortunately, in small-scale fisheries, the middlemen has undertaken the role of the government in terms of subsidies, which makes it more difficult to eliminate the dependence of fishers on external support.

6.2.3 Reducing uncertainty

Uncertainty is one of the main problems faced in fisheries (Gates 1984; Ludwing *et al.* 1991). The varying sources of uncertainty include the dynamic nature of the resource, which is affected by environmental factors, market variation and institutional management arrangements. The variability of the fish population is the first concern that fishers have to face. Miller and Maanem (1979) affirm that people do not accept uncertainty easily, and that they always try to control the circumstances in the most meaningful way. Elimination of uncertainty is impossible, but mitigation could be exerted in different ways, among them by maximization of information. Hilborn and Ledbetter (1985) state that purse seine fishers in British Columbia who do well are those who collect and make an efficient use of information. Fishers interviewed in San Felipe also refer to the importance of accumulating information that can give them some guidance about potential 'good fishing grounds'. They gather this information from informal conversation with other fishers and from their own searching activities.

Cooperation is another way of coping with uncertainty. Beggosi (1996) states that fishers in Brazil cooperate and share information about the more productive spots in order to minimize difficulties caused by an uncertain environment. In my case study, cooperation teams were observed only in Dzilam Bravo. The use of this strategy during the windy season and the lack of consistency in the membership of the teams confirm its nature as a means of dealing with uncertain environmental conditions. Even if fishers from the other ports do not use the same strategy, they might have other forms of cooperation or ways of improving information. For example, in San Felipe, although not everybody acknowledges it openly, some fishers recognize that they cooperate with brothers or other relatives.

The cooperation teams in Dzilam Bravo seem to pay off, albeit only a small proportion of fishers used the strategy in 1992 and 1993. At this stage, this strategy is not widespread, but still remains. Thus, it is important to be aware that this strategy may spread, not only in this port but in others as well. If cooperation cannot be controlled, its potential contribution to an increase in fishing effort should be acknowledged, as it could be substantial if used as a way to increase catches rather than to avoid uncertain environmental conditions.

6.3. Management plans and fishers' strategies

Wilson *et al.* (1994) claim that one of the problems in management is that, traditionally, fisheries have been managed by rules of 'how much can be taken' rather than by evaluating and controlling '*how, when and where'* people fish. They argue that stock assessment has made little contribution to control fishing pressure in many important regions (for example cod on the Grand Banks, haddock and flounder in the Atlantic). They also assert that territoriality and communal tenure system (in which individuals in the community define informal regulations for access and property rights), as well as decentralizations of management can improve the feasibility of implementing management schemes.

Hilborn and Gunderson (1996) contend that the assertion of Wilson *et al.*, about the impossibility of managing abundance of the resources through direct or indirect manipulation of fishing mortality, is equivalent to accepting that fish will die regardless of fishing activity. I emphasise that whatever the approach followed to analyse and manage fisheries, the determination of abundance of the resources is highly relevant and furthermore that reduction of fishing effort, given evidences of overexploitation, is essential. However, the problem comes when fishing effort needs to be defined, measured, and controlled. The challenge in this context is to identify what elements need to be determined, how fishing effort should be considered, and how managers could adjust it in order to obtain an effective response in the desired direction.

Gaertner *et al.* (1999) affirm that factors affecting catchability, such as the fishing power of vessels and/or the skipper's effect, among others, are used in fisheries research to describe 'what things are happening', but not always 'why things are happening'. In the same line, Walters (1993) states that models in fisheries tend to focus on long-term dynamics and seldom try to capture the rapid changes in effort associated with daily decisions of when, where, and what to fish. Understanding of fishers' strategies can help in this regard. I suggest that knowledge of these elements can be incorporated into a framework in a way that could provide feed-back for management plans and definition of regulatory schemes. Many factors may be missing and the causal effect may be difficult to assert in some situations. However, some elements of understanding a fisher's strategies could help to define management instruments more likely to succeed in a particular context.

From the results of my study, and taking into consideration the aspects referred above, I have developed a conceptual framework to illustrate how knowledge about fishing strategies could be used as feedback for modifications and adjustment of regulatory schemes. This knowledge could also facilitate managers' role in designing management plans that would likely be more effective. There are no magic solutions to complex problems, and I do not claim that this is one. The proposed framework simply helps us understand one portion of the 'big picture' that needs to be taken into account when exploring alternative management schemes for small-scale fisheries. Successful management would also require: a) availability of accurate information, b) willingness from the government to incorporate knowledge about fishers' strategies into their policy plans, and c) active participation of fishers in the management process.

It is worth noting as well that there is no one plan that fits all cases, and regulatory schemes should consider the specific contexts. In this regard the implementation of territorial fishing rights (TFR) may help to define programs that can take into consideration the contextual element for different regions. It is important to emphasis that TFR are site specific more than species specific, as they cannot fully enclose stocks along their migratory movements. Under these conditions, community-based management has been suggested as useful management approach in small-scale fisheries (Breton *et al.* 1996; McCay 1996). Sensing security of tenure and the potential benefits that can be derived from it can motivate compliance and commitment for the collective good.

6.3.1. Conceptual management framework

To describe how the knowledge of fishing strategies could be incorporated into management plans, I present a hypothetical example. I assume that there is a management plan that aims to a) maintain the fishing stock, b) generate jobs, and c) maintain stability of fishers' income. Two alternative management schemes are presented (1 and 2), each one generating different results and promoting different responses of fishers. In case 1, it can be assumed that traditional management plans are in place and that they were defined without considering information about fishers' strategies (Figure 6.2). The way to achieve the goals could involve providing subsidies and promoting technological improvements to the fleet to help fishers to enter into the activity (a very common strategy followed in small-scale fisheries to promote development). This situation, coupled with limited restrictions in access to the fishery, could result in increases in catch and profits in the short term, and consequently attract more people into the fishery. As a result, more jobs could be generated in the short term, but also competition can also occur, as more people would be chasing the same resource. Fishers would tend to augment the number of trips to increase their catches or switch between alternative species in order to maintain their income. In the long term, however, reduction of stock biomass would result in reduction of catch rates and hence fishers' income. Competition and overexploitation would eventually generate conflicts and in extreme cases could affect the resources.

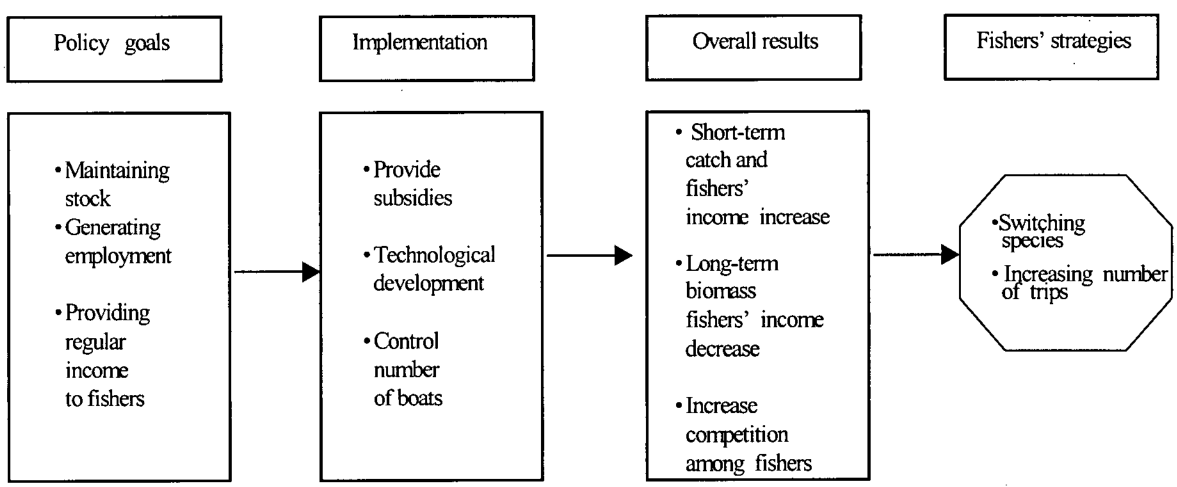

Figure 6.2 Scheme 1. Traditional management framework for small-scale fisheries without considering fishers' strategies. Control of technological development, which varies from increased horsepower, navigational aids, to changed size of boats, etc.

On the other hand, assuming also that from the previous scheme the overall results remain the same, but now fishers' strategies are considered in the definition of management plans, scheme 2 can be put in place instead of scheme 1 (Figure 6.3). The new scheme could include: limiting access to the fishery in terms of areas closure and territorial rights, control on the number of fishers and boats as well as technological changes in the fleet. These changes and the reduction or elimination of subsidies could result in a decrease of the total catch in the short term. However, it could be expected that the individuals' catch rate in the long term would increase, or at least stabilise (after recovery or stabilisation of the stock) and furthermore, fishers' income can also increase. Given limited access, this condition would restrict the use of fisheries as alternative employment for other sectors, or would affect people within the same sector, at least in the short term.

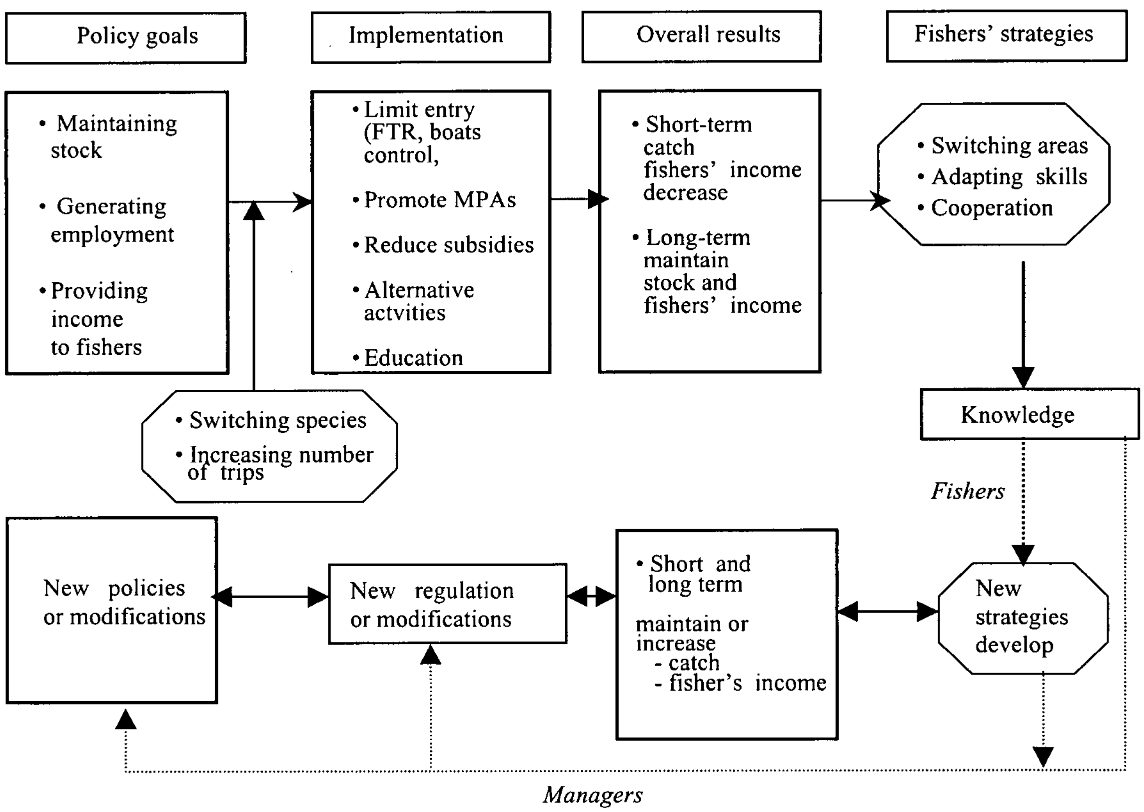

Figure 6.3. Scheme 2. Proposed management framework for small-scale fisheries taking into consideration the fishers' strategies. TFR stands for territorial fishing rights and MPA for marine protected area.

Silvestre and Pauly (1996) state that fisheries management can be seen as a dynamic allocation process, where ecological, economic and institutional resources are distributed with value to the society as the overall goal. Thus, dealing satisfactorily with the problem of achieving economic efficiency usually requires reduction in labor inputs to the fishery. In many cases, there are few realistic prospects for alternative jobs to accommodate the resulting labor supply from somewhere else, at least in the short term. This might make socially unacceptable and politically unrealistic any substantial reduction in the number of fishers employed. However, allowing indiscriminate number of fishers would inevitably lead to overfishing, degradation of the coastal area and marginalization of people (see Pauly 1997). To ensure the implementation of management plans of small-scale fisheries, especially if this involves reduction of the fleet, alternatives for fishers livelihood are necessary. Additionally involvement of fishers in the design of the management plans is essential. High uncertainty in these type of fishers in terms of resource abundance, management, and information available demands cooperation of managers and the communities that depend on the resources.

Given the new management plan, it could be expected that the proposed changes in regulation could lead to the desired outcomes if the conditions stated earlier (fishers' participation, enforcement, etc) are also favored. The new scheme, when imposed on fishers, may not necessarily be perceived immediately as constraints impossible to overcome, as fishers are able to adapt their strategies to comply with new regulations. Within this process, new knowledge in fishers and managers might develop. The former would define new strategies or modify the current ones. The latter could incorporate them in the evaluation and re-definition of policy goals and management schemes. This becomes a dynamic process that needs continuing evaluation, because conflictive management goals, some management objectives have to be stated implicitly, rather than explicitly, because it might not be possible to pursue them simultaneously.

6.4. General discussion

Comparison of different groups of fishers that operate under the same formal fishing regulations, exploit the same resources and are constrained by similar environmental conditions offered an interesting empirical case for the exploration of fishing strategies of small-scale fishers. If homogeneity of fishers is assumed, one could narrowly expect their fishing strategies to be similar in all ports. However, my results exhibit a clear combination of different fishing strategies, namely: switching among alternative species, working in cooperation teams, and increasing fishing efficiency. Even though, fishers from the three ports used two of the identified strategies, I observed significant differences among ports and within ports in their catch profiles. I summarize and discuss in this section those strategies, and suggest some ways in which the understanding of fishing strategies can be useful for fisheries science and management when evaluating small-scale fisheries.

6.4.1. Fishing strategies of small-scale fishers in Yucatán

Switching behavior

Switching among alternative species was common in all the ports studied. Specialization was not confirmed in any of the ports, although some fishers from San Felipe claim to specialize in lobster. A discrete choice model was used for testing linked hypotheses related to the selection of target species. Previous revenues from a particular species and its abundance defined the selection of the target species for the next trip. Economic incentives and fishers' perception about resource abundance showed up consistently as important factors in the selection of target species in each trip. Similar results to those obtained in these studies were reported by Forman (1967), who asserts that in order to maximize production Brazilian fishers rely on their ability to locate particular species according to their market values in different seasons. Davis (1984) also reports that offshore fishers in Nova Scotia (Canada) show seasonal fishing strategies, switching the type of gear ('fine gear' and 'codfish gear') and the species targeted (cod and hake-cod and halibut). He also states that those cycles respond to risk attitude of fishers towards climatic conditions that could affect their equipment or their safety, and as a response to the potential income that could be derived from fisheries like lobster.

Usually, it is not expected that fishers will shift species immediately from one fishery to another which is more profitable. They would first try to incorporate information from past returns of the species available before doing so, because imperfect malleability in switching fisheries imposes a variety of costs. Some of these costs could be monetary, like changing gears, or non-monetary, such as the cost of acquiring expertise in a different type of fishery or moving to different fishing grounds (Bockstael and Opaluch 1984; Palmer and Sinclair 1996).

The cost of switching will vary depending on the level of specialization of the current fishery and the available alternatives. In small-scale fisheries it is more common for fishers to move between fisheries once the fishers have the means to do so. However, this switching is not done randomly. It also involves taking into consideration related costs and prior information. Several studies have emphasized the importance of reference points, which can vary depending on the context (Brown 1995; Guttman 1996). Acheson (1981) states that there are substantial differences even among fishers in the same culture. What appears to be inconsistent and irrational to one group of fishers may be seen as a rational for others. For example, delaying entry to a particular fishery as in the case of fishers in Sisal, could reflect an attitude towards different factors. Every individual evaluates the adequacy of his decisions focusing on the outcomes (monetary and non-monetary) derived from his actions.

Working in cooperation teams

Cooperation teams were identified only in Dzilam Bravo, where they appear to be related to strong winds that could affect fishing operations. During the period analyzed, only a small proportion of fishers used this strategy and the overall effect of the teams on the fleet are not clear yet. However, the reduction in both catch variation and rewards appear to be enough to maintain the strategy in the port.

Regardless of the potential benefits, the cooperation strategy is not as widespread in Dzilam Bravo as may be expected. Even though the strategy seems to pay off for those who make use of it, one wonders why it has not been expanded among more fishers or other regions? Various authors mention several elements that may restrain fishers from cooperating, such as lack of trust, size of the group, ideology, protecting self image and social relationships (Gatewood, 1984b; Gutman 1996; Skaperdas and Syropoulos 1996; Rutan 1998). For example, a large group may reduce the individuals share and increase the risk of cheating whit the consequent mistrust. That is, the distribution of the outputs is determined by the relative amount of resources allocated to each person or group. If one person spends more time than the other in the team, for example, the second individual may be tempted to cheat.

On the other hand, cooperation may have different meanings under different contexts, and the linkages can vary across time. For example, changes in the original conditions can modify the cooperative arrangements. These include changes in the abundance of the resources, access, regulations, etc. Thus, in the short time, people may decide to cooperate for the monetary benefits; but if the distribution of the outputs generated changes, the deal may change. This may be the case for fishers in Dzilam Bravo, who seem to cooperate mainly during the windy season, but rarely at the opening of the lobster season, when people seem to prefer to obtain their own benefits independently.

On the other hand, the relationship between the behavior of fishers in terms of cooperation and seasonal changes of resources abundance is another factor that may play an important role in the way fishers operate. For example, the reported aggregations of octopus between October-November and grouper from January to March in front of Dzilam Bravo could be an incentive to act in a cooperative way. Aggregated resources are hard to locate but provide high reward when found; this risk might be hedged though pooling the catch of two boats (Arreguín-Sánchez pers. comm).

Changes in fishing efficiency

Different fishing performances and fishing efficiency of fishers both among ports and within ports confirm the heterogeneity of fishers in the Yucatán coast. For instance, catch rate and fishing efficiency was markedly higher for fishers in Dzilam Bravo than for the fishers in the other ports. Efficient fishers in Sisal and San Felipe had catches from two to three times higher than the 'average', but in Dzilam Bravo, it was more than ten times higher.

Multiple regression analysis shows that the number of trips, boat length and engine power were related to fishing efficiency in terms of catch and landed value in San Felipe and Dzilam Bravo. Coefficients of fishers' age and experience were also significant in these ports, although they made a smaller contribution than did the trips. In Sisal, it was however mainly fishing trips that contributed significantly to higher variation of catches and landed value than did other factors. Fishers from this port have less experience fishing (no more than 8 years) as they came from rural areas; hence an increase in their labor could be used to compensate for lack of skill.

As suggested in Chapter 1, efficiency can be conceptualized in different ways, depending on the input-output balance. Although, to emphasize the differences in price of the main species caught, I defined here efficiency in monetary terms, nonetheless, maintaining fishers' prestige within the community could also be an incentive to increase catches. This can be observed not only in terms of how much of which species every fisher has caught but also to the challenge involved in the journey (Cove 1973; Gatewood 1984a; Thiessen and Davis. 1988). For example, Newfoundland captains are rated by the crew, and those that perform well are usually preferred and selected (Cove 1973). In this study, although specialization was not confirmed in any of the ports, the folk concept of specialist fishers exists in San Felipe. That is, good divers are acknowledged and can gain some status in the community.

6.4.2. Fishing strategies and decision-making

Small-scale fisheries are characterized by heterogeneity in the productive structure and diversity of boats and gear. Coexistence of diverse fishing strategies gives distinctive characteristics to each fishery. My study provides elements for discussion to show a range of potential fishing strategies observed in small-scale fisheries. The strategies identified in the three ports do not necessarily represent all the strategies operating on the Yucatán coast. There is clearly a fundamental complexity in trying to understand how fishers make decisions in processes that are connected to each other. However, the present analysis provides some insights about the factors related to catch within a fishing season. Determination of fishers' strategies can help to identify changes in exploitation patterns of fishers related to changes in the stock under exploitation.

The permanence of a particular strategy would depend on several factors, among them whether the 'objectives' are met, how constraints can be overcome, the fleet characteristics and the background of fishers. Begossi (1996) suggests that a 'good strategy' will remain as long as it is effective and perceived as such by most of the people. Ferraris (1993) asserts that fishing tactics change or evolve depending in part on the stability of the group and also according to the ability of fishers to adjust to changes.

Opaluch and Bockstael (1984) stress that the different choices occur at different times, and fishers' decisions depend on different factors. They named at least three of those choices: a) fishermen already within some fishery can change their intensity of fishing; b) the distribution of the fishing effort can change through switching among alternative fisheries; and c) effort can change through entry-exit responses. Furthermore, choosing the number of days is a short-term decision, which depends on the levels of return from that particular fishery. Switching between fisheries will depend on relative levels of profitability from the alternative fishery; they define this as an intermediate-run decision. Finally, entering or leaving a fishery is a long-term decision that depends on the absolute level of profitability and relative profitability of the alternative. Because leaving the fishery represents a change of lifestyle as well as investment, economic incentives need to be substantial if fishers are to enter or leave the fishery.

Flexibility of fishers in adapting to alternative options, malleability of the capital invested in the fishery and human capital (skills), and the perspectives of fishers, will define their choices at different time frames, which can vary under different contexts. For example Opaluch and Bockstael (1984) use as their case study fisheries in New England, where fishers can choose between a defined type of fisheries using one specific gear, for scallop, or using a trawling otter. In total, these fishers have between nine and twelve alternatives, thus changing among alternative fisheries could be more costly than for example lobster and octopus in my study. In the fisheries Opaluch and Bockstael studied, they state that switching behavior of fishers involves an intermediate-run decision. This strategy on the contrary may be defined as a short-term decision in the case of small-scale fishers, who are more flexible to shift gears like in the case of fishers of San Felipe.

6.4.3. Potential use of knowledge of fishers' strategies

My study centered on small-scale fishers' strategies, hence from the results derived by my study and from a review of the literature, I maintain that knowledge of fishing strategies could have several potential uses in fisheries science and management. These are: a) to help tune models in fisheries assessment; b) to help implementation of development' programs in fishing communities; and c) to help in the definition of management plans and regulatory measures. I describe some examples and discuss below how knowledge of fishing strategies could be used for the purposes stated. Interpretations of cases other than my particular research are not necessarily expressed explicitly by the authors, but are my own.

a) Fishers' strategies and fisheries assessment

Most fisheries are analyzed independently, regardless of the fact that in many cases fishers operate in common areas where the use of alternative resources often overlaps. Moreover, changes in regulations or other conditions (biological, economical) can also result in redistribution of the fishing effort among fisheries or locations (Walters and Bonfil 1999). In multispecies fisheries, this redistribution, in different areas and time, can be more complicated than when the fishery involves single-species, because the attractiveness of particular fishery may comprise several factors. Holland and Sutinen (1999), state that profit expectations can be quite diverse among individual fishers since the revenues of the fleet as a whole are provided by a variety of species. For example, in the New England trawl fishery, some fishers specialize in a particular species or group of species, but others shift between fisheries throughout the year depending on relative abundance, prices and regulations. Small-scale fisheries in Yucatán operate in a similar manner. Furthermore, predictions of aggregated effort levels of the fleet may provide biased predictions of fishing effort distribution. Hence, fisheries assessment needs to consider observations of fishing effort at different levels as possible (individual, groups, and the whole fleet). For instance, incorporation of fishers' strategies, which can generated changes in the distribution of fishing effort can be incorporated in bioeconomic models, as in the case of the lobster fishery in Cuba (Puga *et al.* 1998). The authors do not make explicit the types of strategies in operation, but adjustment to the components of the catch and fishing effort in the model given the different fishing patterns provided a more realistic view of the fishery.

In my study, the daily catch information allowed me to observe fishing patterns not evident in summarized data. For example, it was clear that fishing trends followed the same pattern as landed value, which is linked to the assortment of species targeted resulting in differences in fishing efficiency and catch rates. This information and the results derived from the choice model and regression analysis can be used as inputs in bioeconomic simulations to evaluate the impact of changes in distribution of fishing effort and prices in the analyzed fisheries.

b) Fishers' strategies and implementation of community programs

There has been a tendency, especially in developing countries for managers to introduce projects or programs to different groups without evaluating their potential effects. For example, at the beginning of the 1990s in some ports of Yucatán, including Sisal, the government promoted the introduction of middle-size boats (between 10 to 17 m). Their goal was to reduce the fishing pressure on the shallow area. As expected, fishers lacked both the training to operate these boats and the tradition of embarking in long trips. Consequently, they operated the large boats as their previous small boats, making a sub-optimal use of them whilst increasing even more the pressure on fishery resources in the shallow area. In this context, knowledge of how fishers respond to different stimuli provides valuable information that would likely help to improve the success or indicate the potential failures of implementing such programs (Russell and Poopetech 1990).

Understanding fishing strategies can be useful to identify channels of communication and levels of organization of different groups. For example, strategies such as cooperation can provide information about the level of cohesiveness or individualism of people. Several authors (Dwees and Hawkes 1988; Knudsen 1995) have suggested that this type of information indicate the flexibility of people in adapting to new situations and adopting technological or administrative changes. Opportunistic fishers with limited commitment to the group may be less responsive to community programs than fishers with larger tradition and stronger attachment to the fisheries.

c) Fishers' strategies and management

An illustration of how understanding fishing strategies could give some insights for management purposes can be seen in the work of Dorn (1997), who did a fine-scale analysis of a trawl fishery. He evaluated the effect of a fishing ban on night in a trawl fishery at in the Pacific hake fishery in the USA. His results showed that fishers accumulated catch during the day, and daily revenues did not decline significantly when a ban was imposed at night; thus, this management strategy did not fulfill its expected purpose.

In the case of the small-scale fisheries in Yucatán, the goal of maintaining the main resources in the long term may not be achieved by controlling only the number of boats or by imposing closures. As observed in this research, because fishers are able to improve their efficiency by increasing the number of trips within a fishing season, these management instruments are not efficiently restricting fishing pressure on the resources. Additionally, heterogeneity between both individual fishers and fishers from different ports calls for the development of alternative management schemes which take into account the impact of changes on one fishery over other fisheries and between different users. Ignoring the interactions of fisheries, coupled with limited long-term enforcement may lead to overexploitation of the resources. Taking into consideration differences of the fishers' strategies can likely improve fisheries management in the region. Control of the number of fishers and boats and consideration of their attributes is required. Geographic restriction of fishing grounds, as in the case of introducing protected areas, could facilitate recovery of resources in the long term, increasing resource abundance which could be reflected in higher catch and revenues per fisher.

Final remarks

To recognize the nature of small-scale fisheries one must see them in their specific contexts. Where it is necessary to reduce the fishing effort, it would be helpful to identify fishing strategies and alternative sources of income both within and outside the fishing activity. Unfortunately, it is common worldwide to pay limited attention to these fisheries, even though they involve directly or indirectly many thousands of people. For example, a workshop organized by FAO in 1998 to analyze fishing effort regulations dedicated no more than two pages to small-scale fisheries (FAO 1998). They were also conspicuous by their absence at the 2nd World Fisheries Congress in 1996. This is understandable, given the economic benefits stemming from large-scale fisheries and the overwhelming phenomenon of overcapitalization in many of the fisheries worldwide. The main problem of small-scale fisheries by contrast, seems to be more related to over-capacity of labor, especially because of migration of people to coastal areas looking for a last source of employment. In these fisheries, then, governments have tended to be more concerned in promoting development programs to palliate poverty than in controlling the effort that seems not yet being perceived as threatening. Additionally, education is basic to create awareness to set the bases of sustainability in coastal areas.

It is necessary to give more attention to small-scale fisheries where migration from rural or other areas can have a long term effect on those looking for better sources of income. Pauly (1996) defines this phenomenon as Malthusian overfishing, as the biomass of the exploited fish population does not increase at the same rate as migration into the area. In particular, he calls for a change of 'mental map' when analyzing these fisheries. Some alternatives that may work for small-scale fisheries in developed countries (e.g. buy-back programs, employment insurance, etc.) may not be applicable to fisheries in developing countries. A combination of powerful tools to access and process information (Preiskshot 1998) might be almost impractical in places like Perú, where the units of catch are registered from 'piezas' (units), to canastas (baskets), 'manojos' (handfuls) or simply as 'dozens' (see Woznitzia 1992). Implementation of fishing quotas is almost impossible in many small-scale fisheries, as the evaluation of the stock size has been limited by imprecise statistics. In this sense, understanding how people operate, and what factors induce them to operate in a particular way are essential in searching for feasible management plans.

6.5. General conclusions

The aim of the present research was to identify and analyze fishing strategies of small-scale fishers and explore the way in which knowledge about these strategies can help in the design of management schemes appropriate for them. The analyses undertaken showed the multidimensional nature of fishing effort and heterogeneity of fishers from the studied ports. It demonstrates the complexity of small-scale fisheries and the problems faced in defining and implementing regulatory schemes.

Although fishers share some of the strategies and are constrained by similar conditions in terms of regulation and environmental factors, significant differences were observed in the catch profiles and the factors that define their fishing efficiency.

Seasonality was an important element related to switching target species and working in cooperation, although fishing efficiency also showed seasonal changes. Factors related to environmental conditions and regulations impose constraints on fishers, who must adapt when evaluating available options for maintaining or increasing their catches and income. Thus, it is important to bear in mind that seasonality is a basic aspect of fisheries research and management of small-scale fisheries.

Daily catch data provided very useful source of information to observe patterns not evident in summarized information. These data, complemented by information gathered by participatory research, can provide pertinent material in the exploration of fishers' strategies in the short term.

Multiple regression analysis and the choice model were useful tools to test hypotheses related to the factors associated with the strategies identified. Some of the assumptions made in this study can be relaxed to expand the analysis, or to explore other types of questions that can provide insights to the understanding of fishers behavior. Logistic regression analysis, rarely used in fisheries analysis, offers a valuable way to explore fishers' behavior.

We have a long way to go before research enables fuller understanding of fishers' responses to changing systems. These aspects should form part of all fishers' assessment for management plans. This research is a step that contributes to such an understanding.

The present study can be expanded to explore the fishing strategies developed by small-scale fishers, especially in terms of their motivations. It may also address some of the issues that arose from my analyses, such as: the identification of social attributes related to the fishing strategies, factors that restrain fishers from participating in cooperation teams, and to identify other forms of cooperation as well.

Since this study is focused on analysis of fishing patterns in the short-term, other series of data in other areas can help to confirm the permanency of the observed patterns and to find out if the relationships observed in this study can been maintained. Use of secondary sources of information in addition to interviews can help to explore detailed facts about fishers' operations and can enrich knowledge about the human component in fisheries analyses. This information is often available from the same fishers and can help to monitor the permanence of a particular strategy and expand the perspectives and type of research develop in fisheries science.

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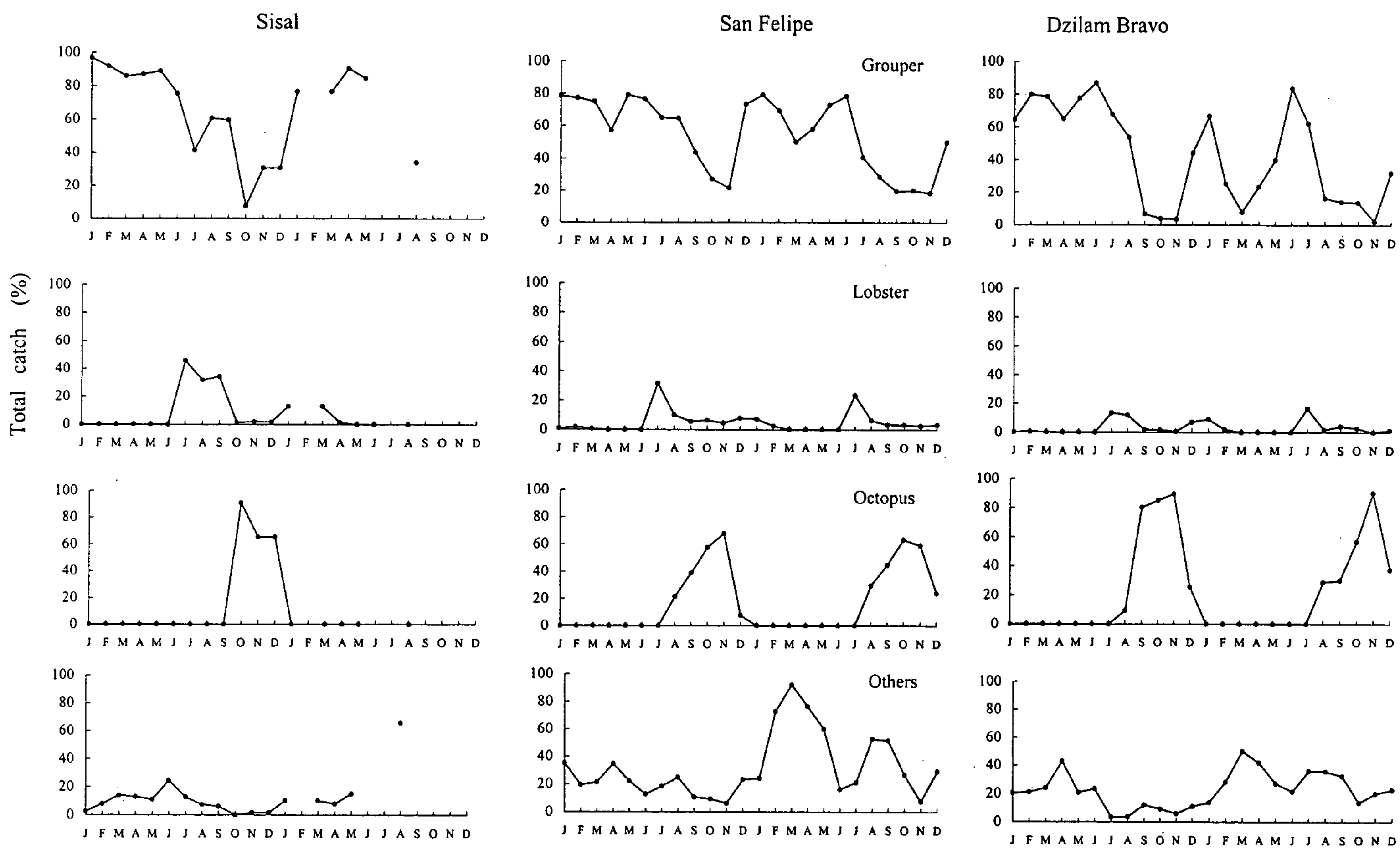
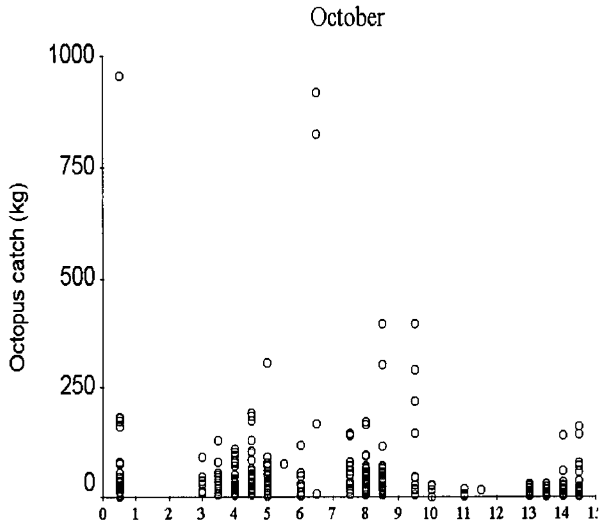


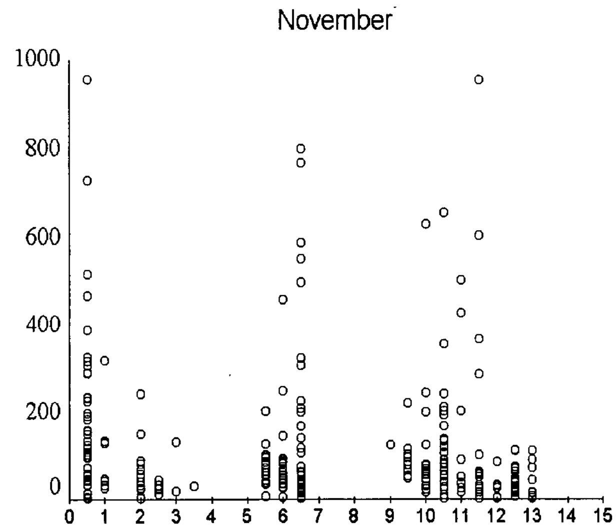
Appendix I.1. Composition of the total catch in three ports of the Yucatán coast in 1992 and 1993.

Appendix I.2. Results of comparison of catch composition among months and among fishers within each port. P=0.001(**) and P=0.005(*).

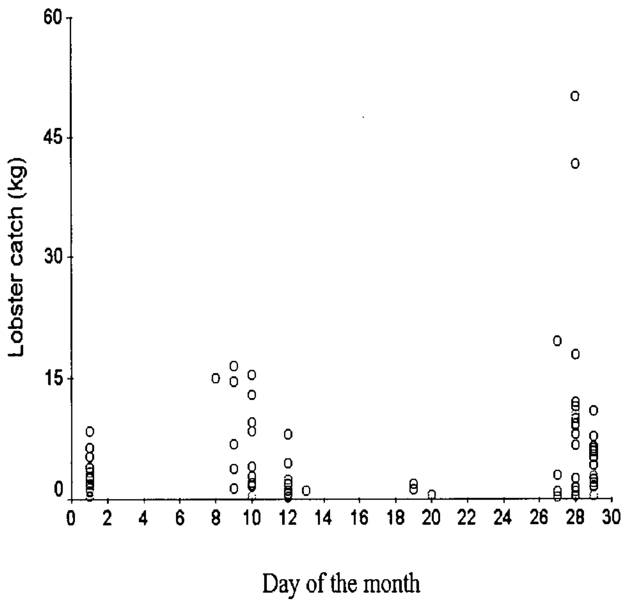
Variation	*Sisal*		*San Felipe*		*Dzilam Bravo*	
	1992	1993	1992	1993	1992	1993
Across the year (N= 18000, df=11)						
Grouper	**25.2	**30.62	**289.3	**368.55	**350.1	**260.03
Lobster	**58.1	**63.28	**278.1	**550.87	**198.5	**232.71
Octopus	*13.6	*11.47	**705.1	**1056.65	**420.1	**554.04
Others	*61.3	**45.58	**118.3	**92.74	**187.3	**226.56
Among fishers						
Grouper	**18.7	**16.62	**490.3	**440.22	**457.0	**267.77
Lobster	**21.2	**10.83	**187.9	**301.26	**365.7	**269.66
Octopus	*10.0	*11.48	**75.4	**94.27	**174.3	**218.19
Others	*9.3	*6.43	**397.8	**426.89	**187.8	**238.19
df	16	14	150	148	99	118

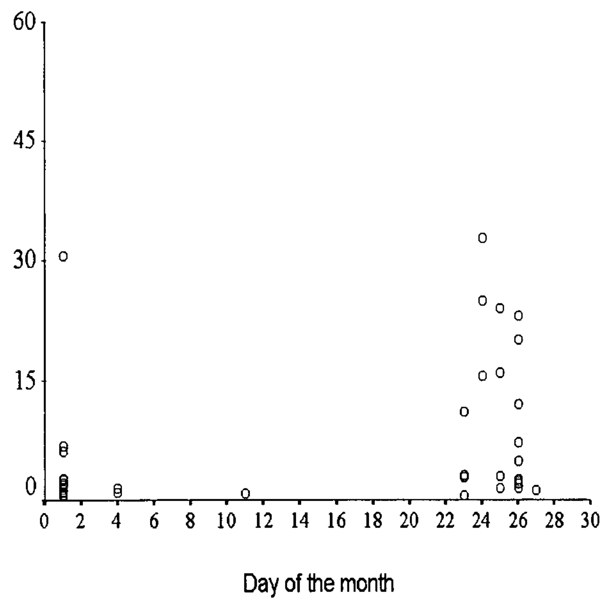
Octopus



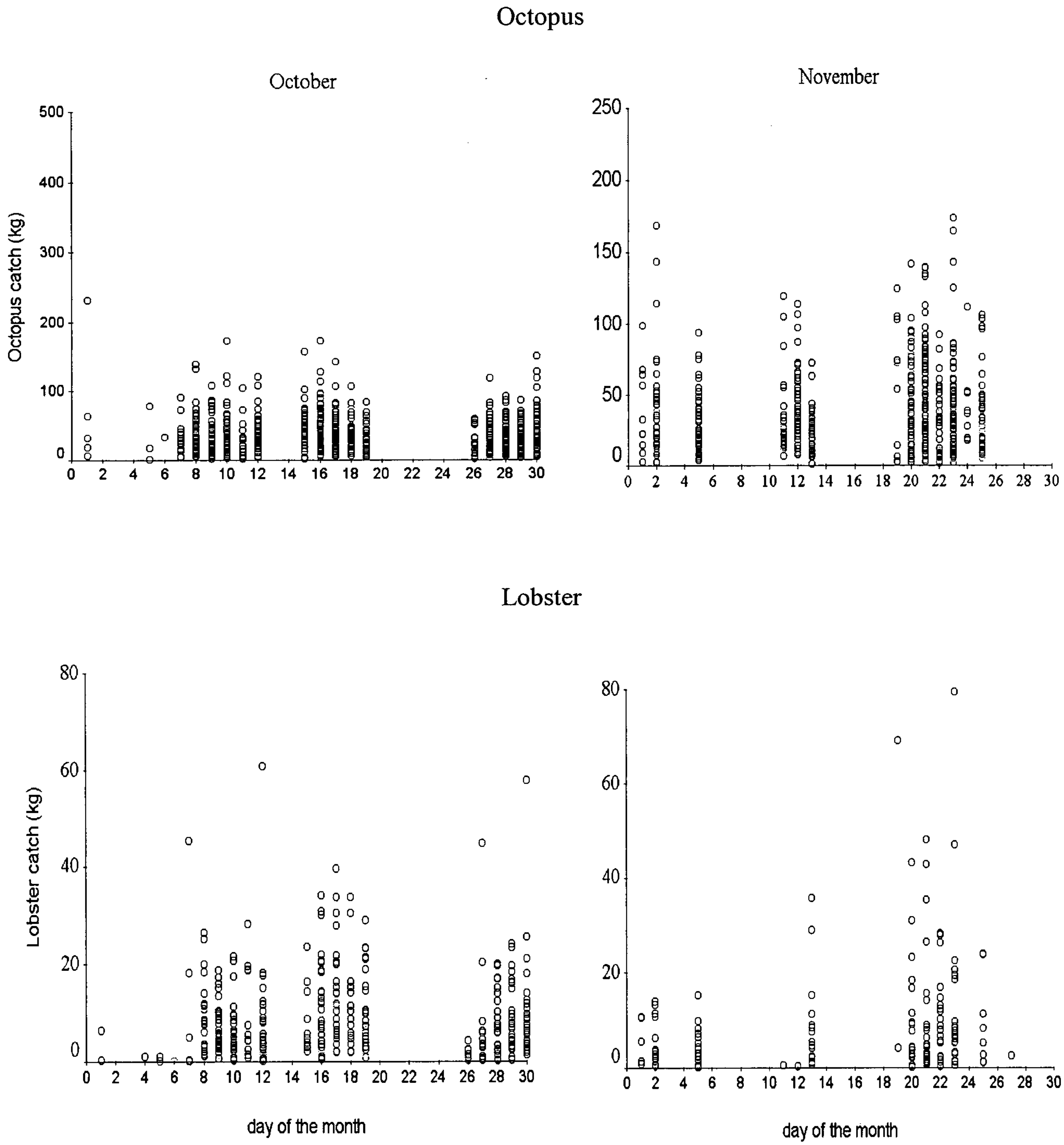


Lobster

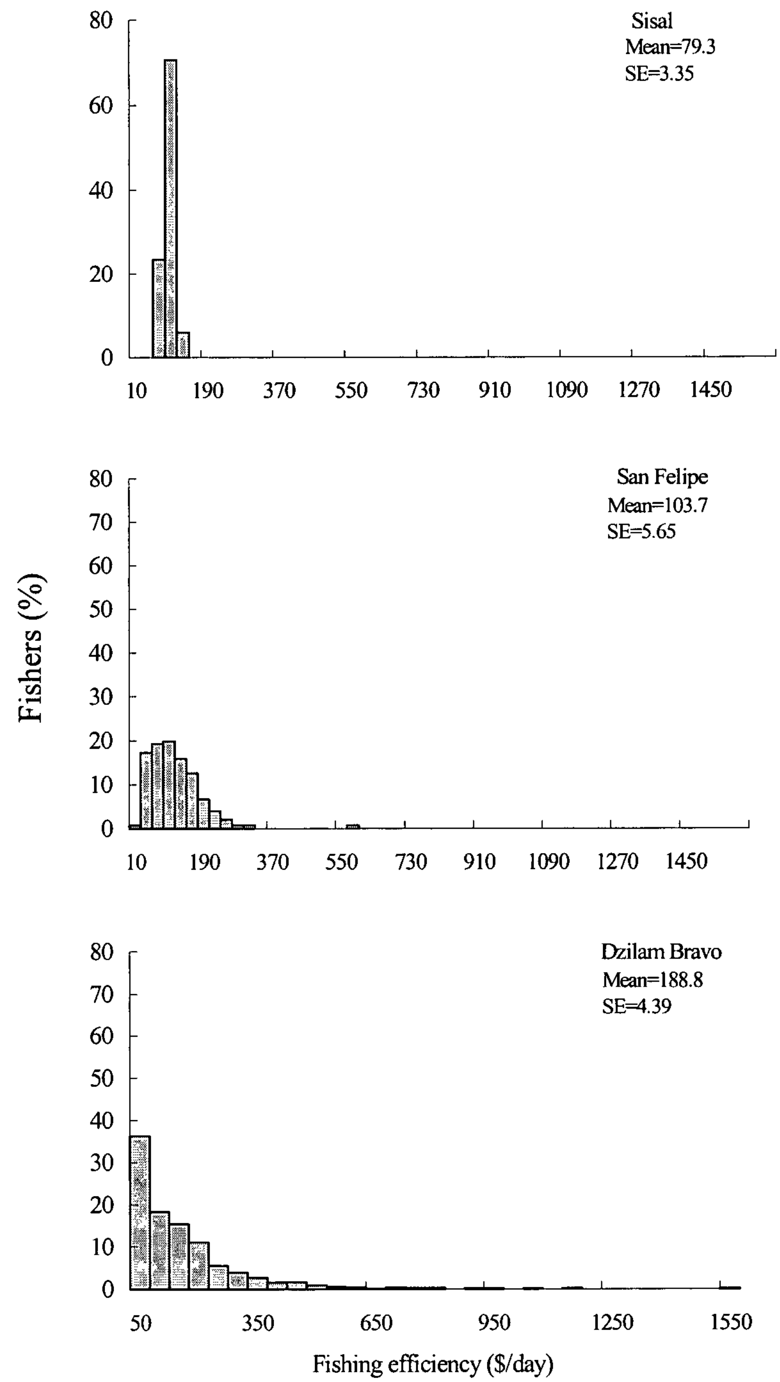




Annex I.3. Daily catch per fisher in Dzilam Bravo in two periods of 1992 as an example. Every dot represents an individual fisher. The range of variation in the catches also indicates differential fishing efficiency among fishers.



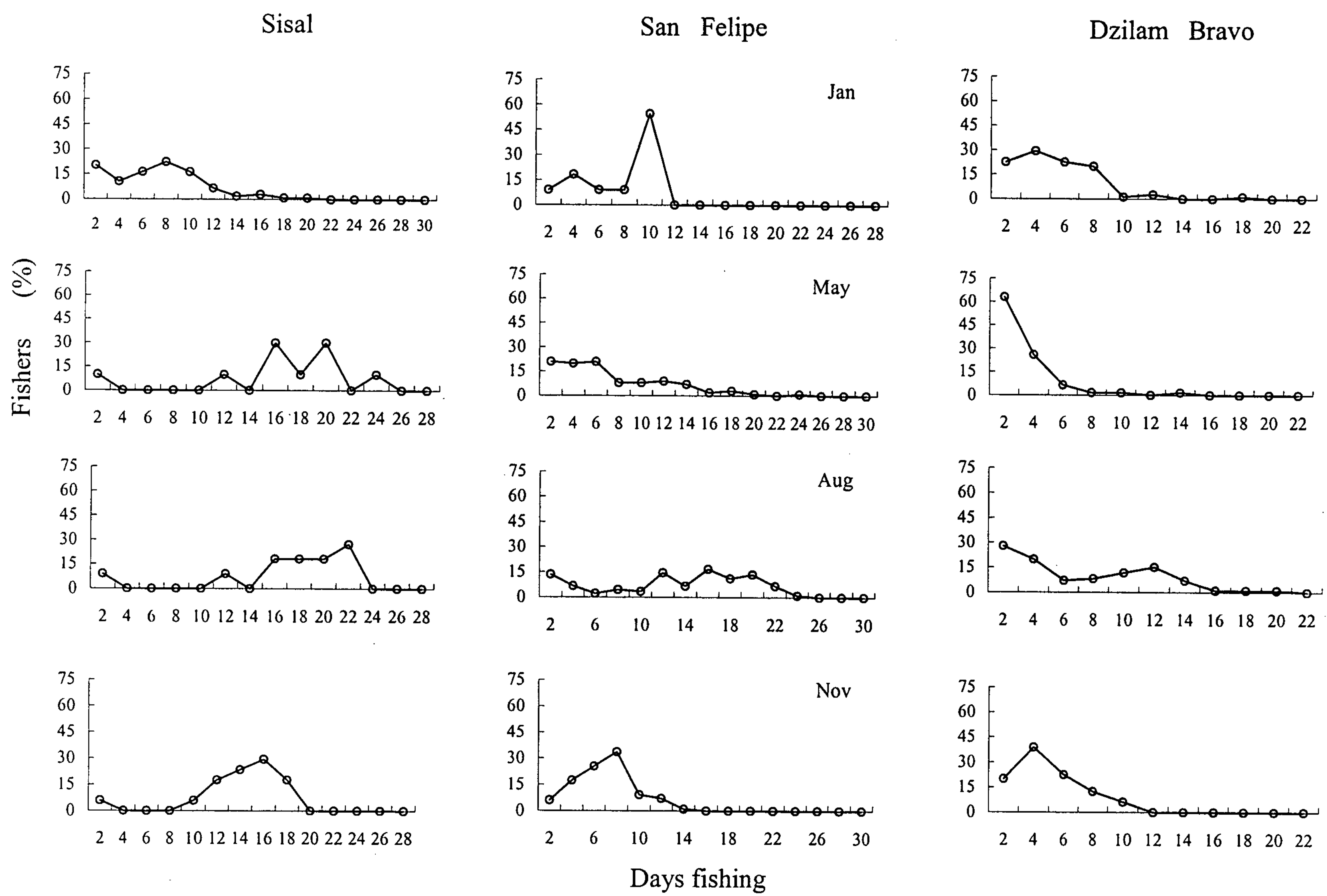
Appendix I.4. Daily catch of individual fishers from San Felipe in two months as example. Shifting from one species to another is not in clusters like in Sisal. Differential fishing efficiency is evident by the wide range of variation of the catch among individuals (every dot represents an individual fisher).



Appendix I.5. Frequency distribution of fishing efficiency of fishers from three port in Yucatán in 1992.

Appendix I.6. Results of comparison of fishing efficiency among months and fishers in three ports of Yucatán (**P=0.001,**P=0.005).

	Sisal	San Felipe	Dzilam Bravo
Across the year	**1992**		
Efficiency	**102.99	**448.96	**193.27
df	11	11	11
	1993		
Efficiency	**35.94	**354.09	**68.61
df	5	11	11
Among fishers	**1992**		
Efficiency	*8.10	**329.89	**530.57
df	16	150	99
	1993		
Efficiency	**16.14	**419.09	**372.91
df	14	148	118



Appendix I.7. Frequency distribution of fishing effort in terms of days fishing per month during 1992 as example in the three ports of Yucatán.

Appendix I. 8. Frequency distribution of fishing effort in terms of days fishing per month during 1993.

SISAL

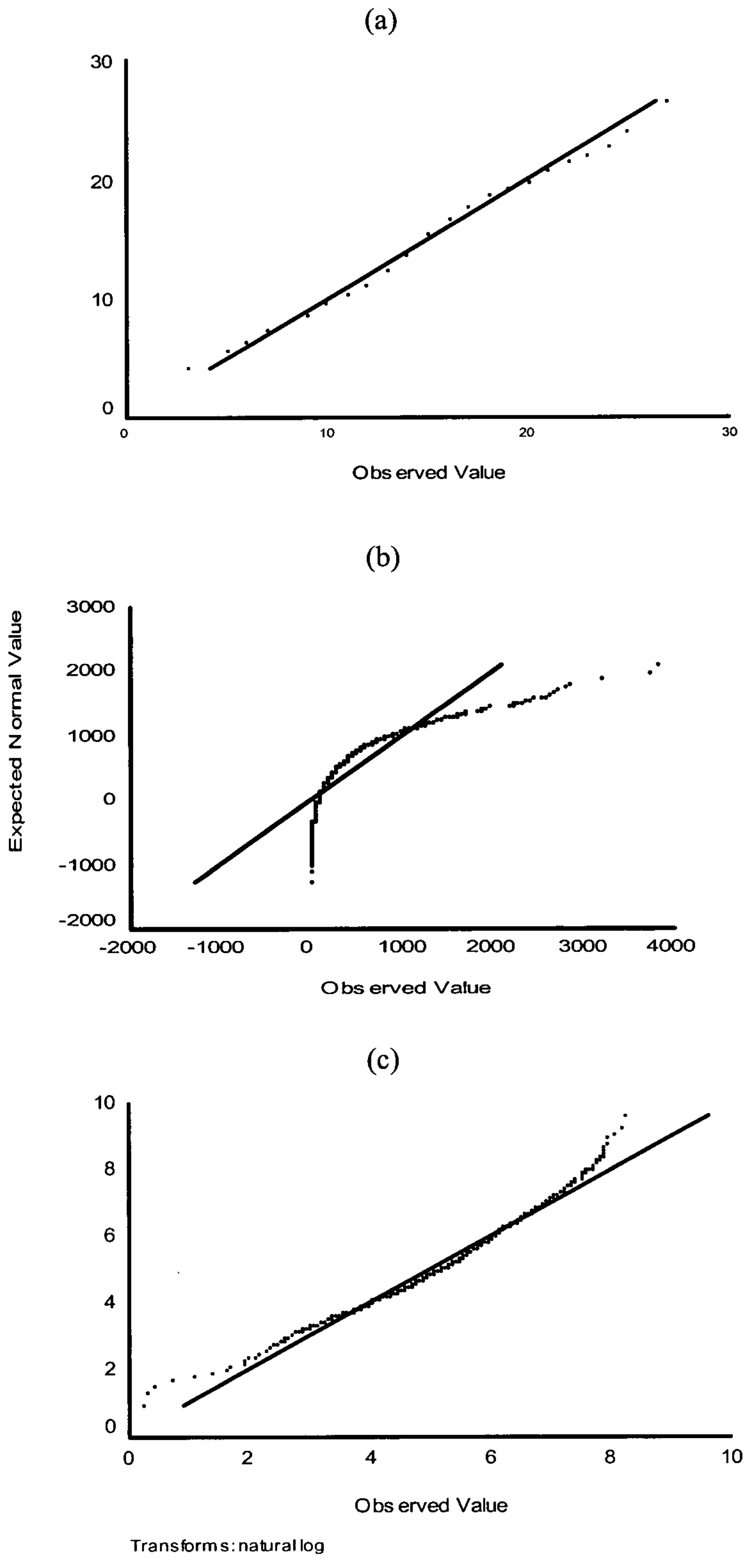
Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	9.1	9.1	18.2	11.1	10.0	10.0	9.1	9.1	9.1	7.7	5.9	6.3
4	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
6	9.1	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0
8	9.1	0.0	9.1	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
10	54.5	9.1	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	6.3
12	0.0	9.1	27.3	11.1	10.0	0.0	0.0	9.1	0.0	15.4	17.6	12.5
14	0.0	27.3	18.2	22.2	0.0	30.0	0.0	0.0	0.0	61.5	23.5	31.3
16	0.0	27.3	18.2	55.6	30.0	10.0	9.1	18.2	9.1	0.0	29.4	25.0
18	0.0	0.0	0.0	0.0	10.0	30.0	0.0	18.2	54.5	0.0	17.6	12.5
20	0.0	0.0	0.0	0.0	30.0	10.0	0.0	18.2	9.1	0.0	0.0	0.0
22	0.0	9.1	0.0	0.0	0.0	0.0	18.2	27.3	18.2	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	10.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	27.3	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	6.3

SAN FELIPE

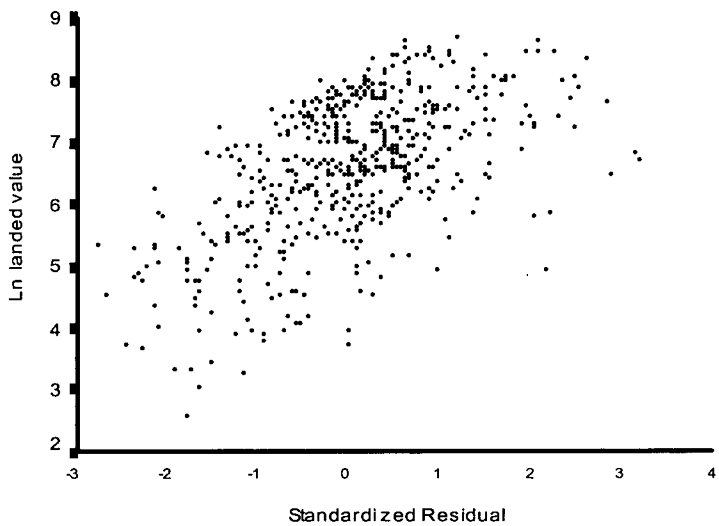
Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	20.4	10.6	28.3	44.5	20.8	29.3	8.0	13.3	9.3	5.3	6.1	15.2
4	10.7	9.6	17.4	25.5	19.8	10.9	3.4	6.7	6.2	1.1	17.3	8.6
6	16.5	14.9	21.7	14.5	20.8	22.8	1.1	2.2	1.0	6.4	25.5	6.7
8	22.3	24.5	17.4	9.1	7.9	18.5	2.3	4.4	5.2	9.6	33.7	10.5
10	16.5	16.0	9.8	1.8	7.9	7.6	1.1	3.3	4.1	20.2	9.2	21.9
12	6.8	12.8	4.3	1.8	8.9	5.4	2.3	14.4	6.2	21.3	7.1	17.1
14	1.9	7.4	1.1	0.9	6.9	3.3	2.3	6.7	3.1	21.3	1.0	14.3
16	2.9	3.2	0.0	0.9	2.0	1.1	2.3	16.7	7.2	11.7	0.0	4.8
18	1.0	0.0	0.0	0.9	3.0	0.0	5.7	11.1	11.3	2.1	0.0	1.0
20	1.0	1.1	0.0	0.0	1.0	1.1	11.4	13.3	15.5	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	13.6	6.7	16.5	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	1.0	0.0	25.0	1.1	8.2	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	18.2	0.0	6.2	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0

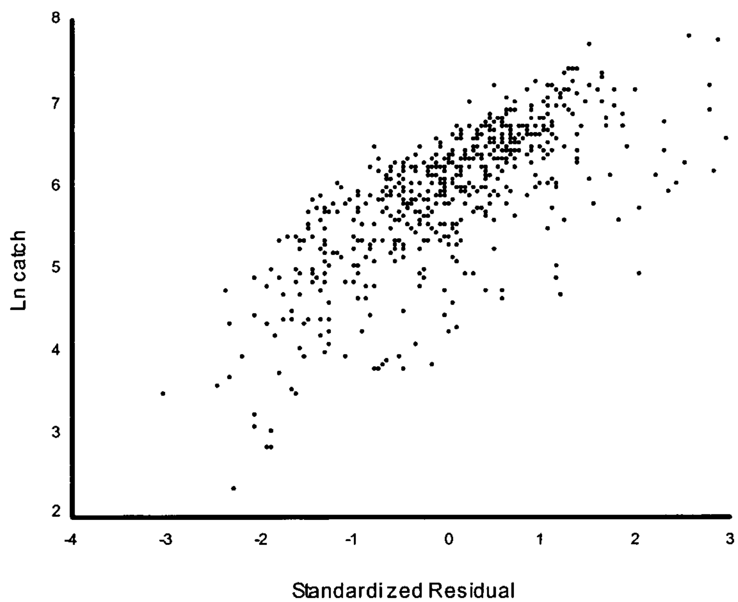
DZILAM BRAVO

Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	22.7	36.9	34.9	63.2	62.9	29.9	28.4	27.9	26.7	25.6	20.0	33.7
4	29.3	20.2	18.1	14.7	25.8	26.0	11.4	19.8	13.3	12.8	38.8	15.1
6	22.7	22.6	20.5	8.8	6.5	20.8	10.2	7.0	13.3	17.4	22.5	20.9
8	20.0	8.3	13.3	5.9	1.6	13.0	5.7	8.1	7.8	26.7	12.5	15.1
10	1.3	7.1	7.2	5.9	1.6	3.9	10.2	11.6	6.7	9.3	6.3	12.8
12	2.7	3.6	1.2	1.5	0.0	2.6	8.0	15.1	12.2	7.0	0.0	2.3
14	0.0	0.0	4.8	0.0	1.6	0.0	9.1	7.0	12.2	1.2	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	1.3	8.0	1.2	6.7	0.0	0.0	0.0
18	1.3	1.2	0.0	0.0	0.0	2.6	4.5	1.2	1.1	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	3.4	1.2	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0



Appendix II.1. Q-Q plot for normality test. As example,
a) trips in Sisal which did not require transformation,
b) total catch in Dzilam Bravo before the transformation
c) total catch in Dzilam Bravo after transformation.





Appendix II.2 Evaluation of residual for multiple regression analysis for catch (top) and landed value (bottom). Dzilam Bravo as an example.

Appendix II.3 Results of comparison of catch and landed value among performance categories (*PC*) and fishers for catch and landed value (Kruskall-Wallis test)

Statistics	*Sisal* *Catch*	*Sisal* *Landed value*	*San Felipe* *Catch*	*San Felipe* *Landed value*	*Dzilam Bravo* *Catch*	*Dzilam Bravo* *Landed value*
PC (df=2)						
Chi-square	22.43	16.51	27.26	183.20	377.24	252.13
N	1964	1924	10099	10099	4926	4926
α	0.001	0.0001	0.001	0.001	0.01	0.001
Fishers						
Chi-square	56.04	59.63	1199.53	1558.58	421.52	333
Df	16	16	180	180	100	100
α	0.000	0.000	0.000	0.000	0.000	000

Appendix II.4 Spearman's correlation coefficient for numerical variables used in the analyses for each port. (Significance (2-tailed) at P=0.05). Boat size not considered in Sisal as all the boats are equal.

Sisal

	Catch	*Landed value*
Experience	*-0.02	*-0.01
Age	*-0.03	*-0.03
Motor power	*-0.07	*-0.09
Trips	*-0.05	*0.64

San Felipe

	Catch	*Landed value*
Experience	*0.10	*0.12
Age	*-0.15	*-0.12
Motor power	*0.09	*0.09
Boat size	*0.12	*0.12
Trips	*0.80	*0.85

Dzilam Bravo

	Catch	*Landed value*
Experience	*0.11	*0.03
Age	*-0.02	*-0.03
Motor power	*-0.01	*0.01
Boat size	*0.34	*0.26
Trips	*0.46	*0.55

Appendix II.5 Results for analysis A. a) Standardized regression coefficients (STDC) and standard error (SE) from multiple regression analysis for catch and landed value as dependent variable and b) summary of regression results. Only significant variables are included. Trips in Sisal were not transformed to logarithmic scale.

Total Catch

	Sisal		*San Felipe*		*Dzilam Bravo*	
	STDC	*SE*	*Beta*	*SE*	*Beta*	*SE*
Constant	5.854	0.16	-4.72	1.72	-2.34	6.47
Age			-0.14	.004		
Experience					0.23	
Ln Boat size	N/A		0.14	0.77	0.13	3.13
Ln Motor power			0.16	0.11	0.15	0.13
Ln Trips*	0.56	0.01	0.77	0.05	0.70	0.10
Species						
Lobster						
Octopus					0.10	0.21
Other					-0.09	0.15
Weather						
Rainy	-0.51	0.11	-0.18	0.07	-0.23	0.07
Dry	0.21	0.13	-0.15	0.07	-0.17	0.69

Landed value

	Sisal		*San Felipe*		*Dzilam Bravo*	
	STDC	*SE*	*Beta*	*SE*	*Beta*	*SE*
Constant	6.32	0.16	-6.57	1.81	-0.71	1.15
Age			-0.14	0.004	0.17	0.07
Ln Boat size	N/A		0.14	0.81	0.07	0.64
Ln Motor power			0.15	0.12	0.15	0.09
Ln Trips*	0.62	0.01	0.59	0.05	0.56	0.05
Species						
Lobster					0.09	0.68
Octopus					0.07	0.11
Other			-0.06	0.19	-0.11	0.16
Weather						
Rainy	-0.39	0.11	0.08	0.11		0.07
Dry	0.17	0.10			-0.21	0.07
Cooperation	N/A				0.19	0.27

Appendix II.5b Summary results from regression analysis splitting by performance category (Analysis B).

	Catch			Landed value		
	Sisal	San Felipe	Dzilam Bravo	Sisal	San Felipe	Dzilam Bravo
R^2	0.72	0.68	0.48	0.53	0.70	0.66
SE	0.32	0.49	0.82	0.34	0.53	0.62
F	43.31	99.04	63.9	46.57	192.6	119.5
N	125	1081	860	125	1081	860

Appendix II.6 Summary results from regression analysis splitting by performance category (Analysis B).

Sisal

	AA	*A*	*BA*
R^2	0.80	0.82	0.74
SE	0.11	0.22	0.16
F	377	95.57	37.2
df	15	81	16

San Felipe

	AA	*A*	*BA*
R^2	0.70	0.90	0.85
SE	0.42	0.39	0.37
F	31.39	157.78	2.63
df	433	407	250

Dzilam Bravo

	AA	*A*	*BA*
R^2	0.72	0.86	0.52
SE	0.58	0.15	0.61
F	35.81	213.00	7.96
df	247	122	492

Appendix III.1 Questionnaire applied to small-scale fishers in Yucatán. Questions from 4 to 7 were included in a daily format which was used for the analysis of choice model.

Bioeconomic and Comparative Analysis of the Artisanal Fisheries
In Yucatán

General information
(Applied during the first interivew with the fisherman)

Interviewer____________________

Port__________________ Date__________

1. Vessels Information.

Name of the boat___________ Owner's name ____________

Characteristics of the vessel:

Length (ft)___________ Capacity (Ton) ________________

Construction: Wood_______ Fiber Glass _______________

Morot type_________

Others____

Purchese: Date______________ Cost___________

Was the Boat new? Yes_________ No_________

If the answer is No, how old was it was when purchased? _________ years.

Motor type: HP___________ Year___________ Cost___________

Manufacturing ___________

2. Gears

Indicate the type(s) of fishery gear used during the year.

Traps ___________ No. _________

Gill nets _____ Length _____ mt. Mesh size of the net _____mm

Lines and fish hooks _____

Long line_____ No._____ Number of hooks_____

Sharks' hooks______ No.______ Number of fish hooks_____

Spoons_____________

Others (specify)____

Indicate the estimated cost and amount purchased by year of the each gear.

Fishery Gear Year Cost Duration

. Traps ____

. Gill nets ____

. Long line ____

. ' Tiburonero' ____
(Nets for sharks)

. Lines & fish hooks_____________________________________

. Spoon ____

. Other ____

3. Information about the crew

Average number of crew members on board of the boat___________

Indicate the way of payment of the crew

. Daily salary __________

. Percentage of the capture __________

. Salary and percentaje of the capture __________

. Other (specify) ____

4. Seasonal fisher effort and capture

List species target and incidental species fihed commonly during the year. And in your last trip.

Objective Specie Incidentals Season

____

____

____

____

____

Effective fishing time ____________
Average number of effective days of fishing per trip ________days
Average number of effective hours per day________ hours

Departure time_________________

Arrival time___________________

Indicate the average number of fishing trips per year for each one of the target species

Target species	Season (month)	Trips (per month)

5. Destiny of the capture

Generally What do you do with the capture?

Destiny	%
. Family consumption (living)	________
. Sold to the local market for fresh consumption	________
. Sold for posterior process	________
. Sold for the exporting market	________

6 . Information about costs

Please, indicate the following costs of the last fishing trip:

Operation Costs	Amount	Price	Total
Gas			
Oil			
Ice			
Food			
Water & Beverages			
Bait			

Labor costs

Salaries______________ Crew (No.)_______________

Total_____________

Capture percentage __________________%

Other Annual Costs	Amount
Craft Mainteinance	______________________
Spare parts	______________________
Replacement of fishing arts	______________________
Mainteinance and repairments of motor	______________________
Cooperative fees	______________________
Other costs	______________________

7: Revenues
Average price of the species landed

Species (Target and incidental)	Average Price (dollars/Kg)

Appendix III.2. Summary results from the logistic regression by port for economic (Eco) and Fishers' perception hypotheses (FP). Variables include: Previous CPUE for lobster and octopus (*$PCPUE_L$* and *$PCPUE_O$*), opportunity costs (*OC*), travel cost (*TC*), and weather for rain (*Wr*).

	Sisal			
	ECO		*FP*	
Variable	*SE*	*p*	*SE*	*p*
constant	0.780	0.730	0.510	0.100
PR_O	0.570	0.120		
$PCPUE_L$			0.100	0.005
$PCPUE_O$				0.020
TC	0.030	0.020	0.04	0.000
OC				
W_r	0.680	0.010	0.0700	0.010

	San Felipe			
	ECO		*FP*	
Variable	*SE*	*p*	*SE*	*p*
constant	0.780	0.730	0.710	0.100
PR_O				
$PCPUE_L$			0.023	0.008
$PCPUE_O$		0.003	0.070	0.015
TC		0.020		
OC	0.030	0.020	0.030	0.004
W_r	0.005	0.030	0.060	0.000

	San Felipe			
	ECO		*FP*	
Variable	*SE*	*p*	*SE*	*p*
constant	0.550	0.090	0.096	0.070
PR_O	0.080	0.002		
$PCPUE_L$				
$PCPUE_O$			0.520	0.000
TC	0.050	0.002		
OC	0.100	0.001	0.04	0.001
W_r				