Status of lobster fisheries and their management in the Sultanate of Oman.

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Status of Lobster Fisheries and their Management in the Sultanate of Oman

M.Phil Thesis

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This Thesis Work is

Dedicated to

His Majesty

Sultan Qaboos bin Said

ABSTRACT

Spiny lobsters constitute an important fishery in the Sultanate of Oman for nearly three decades. The landings declined sharply in the last decade and continuation of poor landings might impact the socioeconomic well being of the lobster fishermen in the country. Hence a decision was made to investigate the causes of decline and offer possible solutions to manage the lobster fishery sustainably. In this regard, the researcher obtained scientific and statistical data to investigate the current status of the lobster fishery and conducted a socioeconomic survey among the lobster fishermen to validate the findings. Management strategies were outlined based on the findings and the researcher's previous experience.

In Chapter 1 a review, based on the literature, was made of the general biology of spiny lobsters, their fishery management and stock enhancement techniques. The review included all of the known, published work arising from studies conducted in Oman.

In Chapter 2 the history of the Oman lobster fishery was described from its origins to the present. Evidence was presented which showed that the fishery was relatively open to entry and that fishermen can equip themselves for lobster fishing with little capital outlay. These factors make the fishery an attractive option in a region of high unemployment. Current regulations were described and the problems in implementing these regulations discussed. The reasons for the decline in the lobster fishery were documented and shown to be linked to a number of factors. The lack of trained government manpower to monitor the fishery and apply regulations, inappropriate changes in the permitted fishing season and the continued use of illegal tangling nets were identified as major factors in the decline of the fishery.

In Chapter 3 a detailed analysis was made of the size structure of spiny lobsters. The data used in the study had been collected by government officials from the four main landing areas for lobsters. The results clearly indicated the scale of the problem relating to the harvest of undersize lobsters. The combined data from these landing areas and over two years revealed that 52% of all harvested lobsters were under the legal size. The problem of harvesting undersized lobsters was discussed within the context of stock sustainability.

Chapter 4 detailed the design of an appropriate socio-economic survey and sampling plan to examine the roles of the fishermen in lobster fisheries management. A detailed questionnaire was developed and the practical difficulties of carrying out a survey in southern Oman described. It was concluded that the survey worked moderately well and provided some useful results. There was clearly further scope to elaborate the study in the future in order to investigate some of the unanswered questions.

In Chapter 5 the results of the socio-economic survey carried out between August and December 2004 were presented. The main aspects assessed were demographic attributes, gross income, crew numbers and their assets for fishing. The survey revealed an ageing population of fishermen who were largely illiterate and had varying sized families. The fishermen were using small open vessels with 2-3 crew members and powered by 40 HP outboard engines. The survey also revealed the illegal employment of expatriates and the frequent use of illegal tangling nets.

In Chapter 6 the attitudes of the fishermen to lobster management issues gathered in the survey were discussed. Ninety three percent (93%) of the fishermen sampled agreed that catch per unit effort was declining and 95% of the fishermen were aware that lobster resources were declining. The majority of fishermen believed that use of illegal nets was the main cause of stock depletion followed by commercial fishing vessels.

In Chapter 7 recommendations were made for an improved regulatory framework for the spiny lobster fishery in Oman. This was based on the author's previous fishery experience and knowledge of changes within the lobster fishery, published information and lobster management plans developed elsewhere and the results of the present study. These included recommendations that further biological, environmental, social and economic knowledge must be acquired and integrated into long-term management plans; that all stakeholders in the fishery must be engaged in the development of a lobster management plan; and that public awareness of the benefits of a sustainable spiny lobster fishery must be developed through new educational and extension programmes.

DECLARATION

This work has not previously been accepted on substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed..... (candidate)

Date .....

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated.

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed ..... (candidate)

Date .....

STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed ..... (candidate)

Date .....

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One Rial Omani (R.O) is equivalent to approximately 2.6 US Dollars and 1.35 UK Sterling Pounds.

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GENERAL INTRODUCTION

SPINY LOBSTER FISHERIES

Fisheries have traditionally been regulated through governments yet in spite of these regulatory efforts the common property nature of fisheries resources has often resulted in overexploitation (Blundon, 1999). This research study examines the status and management of one of the most highly valued fishery resources in the Sultanate of Oman – namely the spiny lobster *Panulirus* sp. fishery.

Lobsters are considered one of the most valuable and popular of fished species and have been in great demand for many years on world markets (Williams, 1988). While the catch per unit effort for many lobster fisheries has declined significantly, the demand for lobsters and the market value of the catch continues to increase (Ford, 1980; Phillips and Brown, 1989). This means that the lobster fishery is likely to fall into the over-exploited category. Escalating demand over the past two decades spurred the need for more effective management and increased research on which to base the management of lobster fisheries (Phillips and Kittaka, 2000).

Spiny or rock lobsters are the focus of this research study. Lobsters in Oman belong to the family Palinuridae represented locally by two species, *Panulirus homarus* and *Panulirus versicolor*. The following sections present an overview of spiny lobster fisheries worldwide and their current status in Oman.

Spiny lobsters are captured and marketed in more than 90 countries and the world catch in 2002 was in excess of 78,000 metric tonnes with a landed value of approximately US $500 million (FAO, 2004). The principal lobster producing countries are Australia, New Zealand, South Africa, Cuba, Brazil, Mexico and the USA. Of the commercially captured palinurid genera, *Panulirus* contributes about 29% followed by other palinurids like *Jasus* 4.3% and *Palinurus* 2% (FAO, 1997). The catch is dominated by the Caribbean spiny lobster *P. argus* (50.8%) followed by western rock lobster *P. cygnus* (15.3%),

green rock lobster *J. verreauxi* (4.9%), red rock lobster *J. edwardsii* (4%) and the Cape rock lobster *J. lalandii* (2.8%).

Worldwide, palinurids support both commercial as well as local, small-scale fisheries in remote coastal locations. Capture methods for palinurids are diverse, including the use of traps, nets of various types, spears and skin diving (Bowen, 1980). Some of the palinurids form the basis of large commercial fisheries, such as *P. argus* in the Caribbean, *P. cygnus* in Western Australia and *Jasus* in New Zealand.

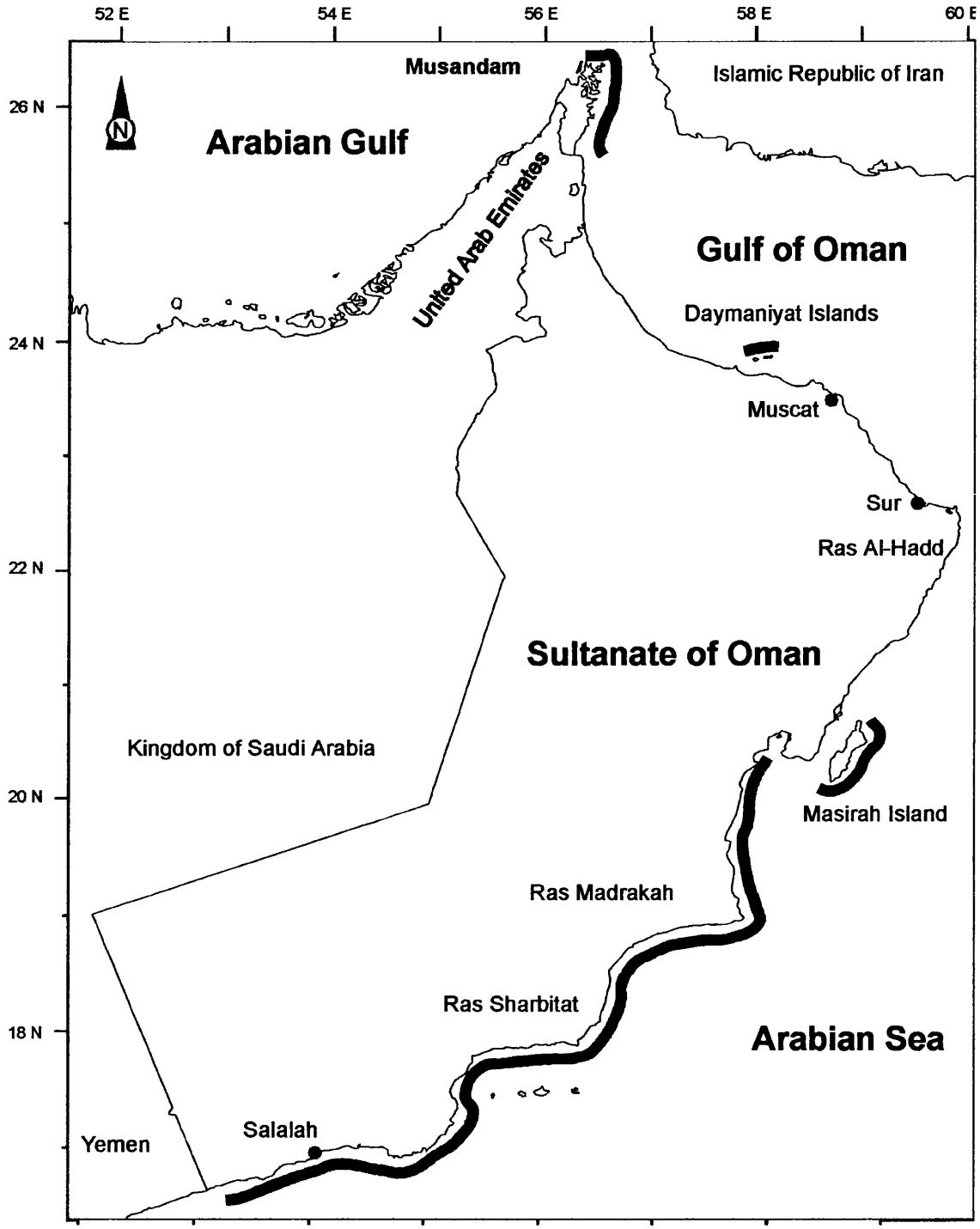
LOBSTER FISHERIES IN OMAN

Oman, a semi arid country, lies at the southern corner of the Arabian Peninsula (Appendix II). Until the early 1980s lobsters were plenty in Omani waters, especially in southern Oman. They were left largely untouched by fishermen[1], possibly due to a lack of awareness of their commercial value. However, the fishery has expanded rapidly in the last two decades.

The lobster fishery in Oman targets *Panulirus homarus* although *P.versicolor*, are also taken. *P.homarus*, the scalloped spiny lobster species, is distributed along the Arabian Sea coast from Dhalkut in the Dhofar region to Ras-al-Hadd and Masirah Island (Fig. 1). In recent years most of the lobster catch has come from the Dhofar region (Mohan and Al-Amri, 1998). As the previous authors stated further stated, *P.versicolor* is restricted to the northern part of Oman, particularly the Musandam region and accounts for just 5% of the total lobster landings.

In recent years, the fishery has been characterized by a steady decline in landings, from more than 2000 tons in the 1980s to just 233 tons in 2004 (Ministry of Agriculture and Fisheries, 2004). Lobsters have become rare in some regions, like Al -Wusta which was once the highest catching area, due to overfishing and illegal use of tangle nets (Anon[1], 1997). In fact, management regulations designed to protect this fishery are rarely enforced.

[1] Throughout this thesis the term fishermen refers to fishers



Source: Department of Marine Sciences, Sultan Qaboos University, Oman.

Fig. 1. Map showing main fishing areas of spiny lobster in Sultanate of Oman (Shaded areas)

SCOPE OF THE PRESENT STUDY

The present study was selected to address some critical issues pertaining to the status of the lobster fishery in the Sultanate of Oman. Although, there are many seafood species of commercial importance and a number of them are showing continued decline in landings, lobsters are selected for this study as only a few studies have been carried out in Oman to date and none of them are particularly related to the management of the lobster resource.

Initially, when the fishery started in 1980s, the catches were very good and the fishery attracted increased investment from processing companies and traders. This in turn resulted in increased fishing effort resulting in a sharp decline in catch rates. There is now a serious concern that the resource may have been overfished. The present situation warrants a more balanced approach to lobster fishery management through improved responsibility of the stakeholders to ensure long term sustainability of the resource which is in the best interest of the nation.

The present study shall focus on the fisheries management of lobsters, in particular the spiny lobster, *Panulirus homarus*. This research could provide a framework, which might assist the statutory authorities in implementing a more effective management plan to protect and improve this valuable resource. In this regard the researcher identified some research questions that need to be examined and the outcome analyzed.

1. Do the fishermen's economic dependence and family size influence the attitude of these fishermen?
2. Do age, education levels and other social identities have direct effects on resource status and the fishermen's willingness to cooperate?
3. Are the fishermen aware of the declining status of the lobster resources?
4. Are the fishermen aware of the causes of this decline?
5. To what degree are these fishermen willing to cooperate with the government and amongst themselves?

THESIS APPROACH

The study covers a review of literature (Chapter 1) on lobsters and their biology, ecology and management worldwide and compared to the situation in Oman. This is followed by a brief introduction to the current status of lobster fisheries in Oman (Chapter 2). In the 3rd chapter, the author presents a case study in which lobster size class is discussed from the field data collected to interrogate the researcher's hypothesis that the fishery is in a state of decline due to inappropriate management.

The results of a socioeconomic survey of lobster fishermen in Southern Oman, which was carried out between August and December 2004, are reported in Chapters 4, 5 and 6. Chapter 4 describes methods used to elucidate facts and values from the lobster fishermen. This was the first such survey conducted by the researcher, and it was carried in a remote and harsh part of the country. However, because of previous practical experience in the fishery over many years, the author is confident in the factual content of the results (see chapter 5), even if, with hindsight, the research methods might have been improved. Chapter 6, conveying the attitudes of fishermen, is perhaps the most important from a policy point of view; fishermen are aware of the decline in lobster stocks and many understand some of the reasons for this. This constitutes a basis for further policy development.

Finally, the 7th and concluding chapter will address Oman's past management approach and suggest recommendations which, if implemented, may contribute to the more effective management of the lobster resource in Oman.

The researcher conducted library searches for information pertaining to this thesis and has accessed key peer reviewed papers.

CHAPTER ONE

LITERATURE REVIEW

In this chapter, a general review is presented on the biology of rock lobsters with emphasis on those aspects that influence management practices. This is followed by a detailed review of spiny lobster fisheries management and stock enhancement techniques. This is largely based on information from countries with well-documented management policies, but also includes reference to all of the original work, which has been conducted to date in Oman.

1.1 CLASSIFICATION AND DISTRIBUTION

The infra-order Palinura is composed of three distinct superfamilies: the Erionoidea and the Glypheoidea, which are both rare, and the Palinuroidea, which divides into three families. These are the Palinuridae, the spiny lobsters; the Synaxidae, the furry lobsters and the Scyllaridae, the slipper or shovel-nosed lobsters (Holthuis, 1991).

Spiny or rock lobsters of the family Palinuridae lack the claws of true lobsters, e.g. *Homarus*, but have spine covered carapaces and antennae, which are used in defense. They are common throughout the tropics and subtropics and eight genera are recognised (Holthuis, 1991). Species of the genera, *Jasus*, *Palinurus* and *Panulirus* form the commercial and recreational fisheries (Lipcius and Eggleston, 2000). Table 1.1 shows the major lobster fisheries around the world.

1.2 GENERAL BIOLOGY

1.2.1 **Life History**

Female rock lobsters typically become sexually mature within seven years. Following the female pre-mating moult, the fringing setae of the pleopods grow longer in preparation for egg laying and attachment. During mating the male releases spermatophores which attach to the ventral side of the female. Within the cephalothorax of the female up to one

Table 1.1 Major fisheries for palinurid lobsters (Adapted from Phillips and Kittaka, 2000)

Panulirus	Palinurus	Jasus	Geographical location	World Catch (mt)	% of palinurid catch
argus			Caribbean, Florida, Brazil	38,020	50.8
Panulirus spp.*			Ecuador, Panama, Brazil, East Africa, Indonesia, New Guinea, Pacific Islands, Thailand, India, SE Asia, NW Africa, Oman	10,677	14.3
japonicus					
longipes			Japan, South China Sea China, Japan	1,267	1.7
cygnus			Western Australia	11,450	15.3
	delagoae		SE Africa, Mozambique	294	0.4
		verrauxi	East Australia, New Zealand	3,689	4.9
	mauritanicus		West Africa, Mauritania	2,886	3.9
	gilchristi		South Africa	962	1.3
		edwardsii	New Zealand	3,014	4.0
		lalandi	SW Africa, Spain	2,129	2.8
		tristani	Tristan de Cunha, St Helena	363	0.5

*Includes *Panulirus homarus* of Oman.

million orange eggs become mature and are released through pores at the base of the third pair of walking legs. They are fertilised as they are dragged across the spermatophores by water currents created by the pleopods. The eggs then attach to the long setae on the pleopods and the female, now carrying fertilised eggs, is described as 'berried' (Lipcius and Herrnkind, 1987; King, 1995).

Egg numbers may vary according to the size of the lobster and the numbers of spermatophores transferred during mating (Gardener & Frusher, 2000). Studies of the fecundity of scalloped spiny lobsters, *P. homarus*, in Oman revealed egg masses of

between 35,000 and 750,000 carried by individual females (Mohan and Al-Amri, 1998). Incubation periods for eggs are relatively short, from three to five weeks (Cobb and Wang, 1985; Marx and Herrnkind, 1986), whilst the period of larval development, from egg to the puerulus (Fig. 1.1), is long, ranging from a few months up to two years (Phillips and Sastry, 1980).

Egg masses are generally spawned and hatched in the spring and summer. Unlike other crustaceans, eggs of spiny lobsters pass through a naupliar phase before hatching into the distinctive phyllosoma larvae (Sastry, 1983), which are transparent and measure about two mm in length (CSIRO, 2003).

Spiny lobsters have long pelagic larval phases of up to two years, during which the larvae may be transported long distances offshore by ocean currents (Zacharin, 1997; Griffin, 2004). After the extended phyllosoma larval stage (Fig. 1.1) deeper offshore waters, they gradually metamorphose to the puerulus larval stage. By this stage the larvae resemble the adult stage but lack colouration and are transparent. The puerulus larvae are capable of swimming towards the coast where they settle into small holes and crevices in the reefs and seabed (Johnson and Al-Abdulsalaam, 1991; CSIRO, 2003). The number of pueruli settling on the fishing grounds every year may depend on the success of the previous year's migration and breeding (Phillips *et al.*, 2000). The settled pueruli moult into small juveniles, with a carapace length of 8 mm (Phillips, 1981). Studies from Oman have indicated that the larval period of scalloped spiny lobsters extends for approximately eleven months (Johnson and Al-Abdulsalaam, 1991).

Spiny lobsters are about 2 years old when they settle in shallow coastal reefs as pueruli. Within 3 –5 years, they move offshore into deeper waters, where they reach the minimum legal size and enter the fishery. Hence, they are 4, 5 or 6 years of age at recruitment to the fishery (Phillips *et al.*, 2003). After 4 to 6 years spiny lobsters migrate offshore from the shallow reefs to outer continental shelf at depths of 30 – 150m, where the reproductive cycle begins once more (Phillips and Brown, 1989). Fig. 1.1 shows the life history pattern of spiny lobsters.

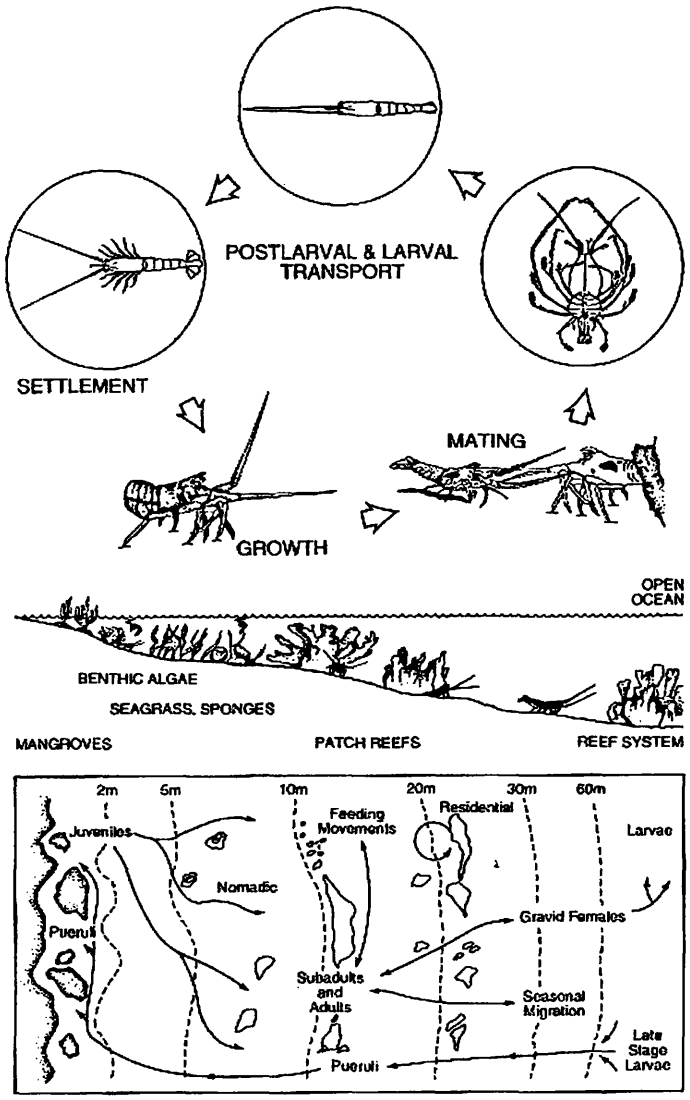


Fig. 1.1 Life cycle of palinurid lobsters (Phillips and Kittaka, 2000)

1.2.2 **Morphology**

Spiny lobsters are among the largest of crustaceans. Total body length may exceed 60cm (Lipcius and Eggleston, 2000). Body parts are divided into cephalothorax, which consists of the fused head and thorax, and an abdomen with their respective appendages (Phillips and Kittaka, 2000). Appendages on the cephalothorax include the eyes, the antennae and antennules, which provide protection, mechanoreception and chemoreception (Lipcius and Eggleston, 2000); the mouthparts, which include the mandibles, maxillae and maxillipeds; and five pairs of walking legs. The ventral portion of the cephalothorax forms a sternum, which bears the gonophores at the bases of the 3rd pair of pereiopods in females and 5th pair in males (Fig. 1.2).

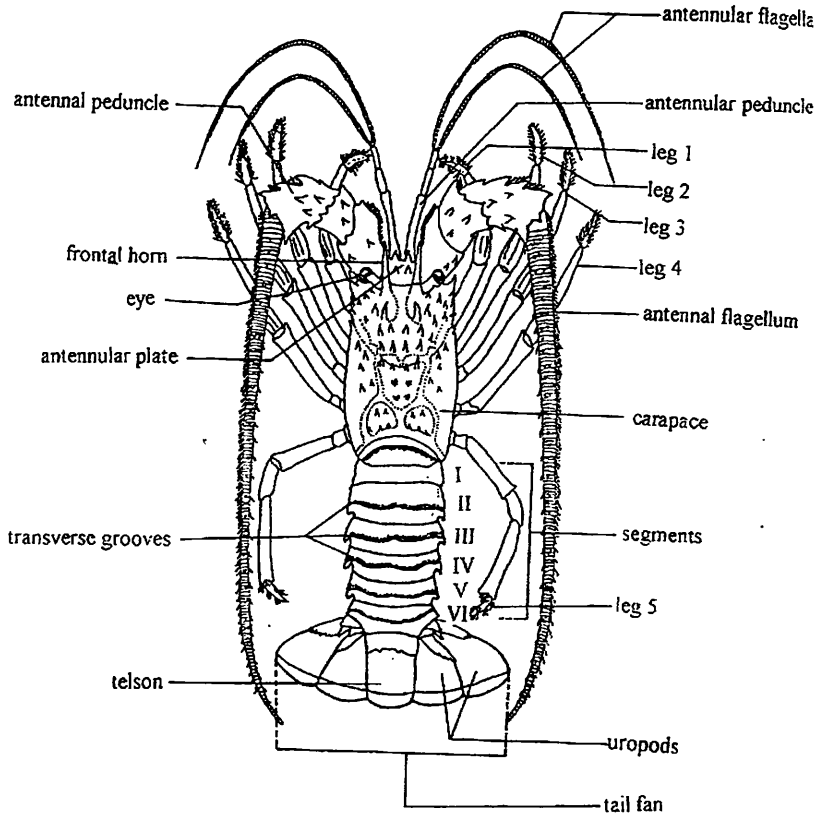


Fig. 1.2 Morphology of palinurid lobsters, Dorsal View (NIOT, 2004)

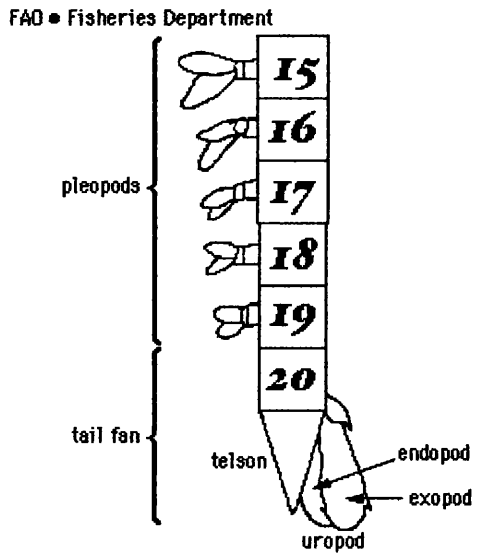


Fig. 1.3 Morphology of P. homarus (Holthuis, 1991)

On the abdomen of the male, the first two pairs of pleopods are often formed into copulatory organs, whereas in mature females the pleopods become setose to enclose the external egg mass (Lipcius & Herrnkind, 1987). Posteriorly, the 6th abdominal somite forms the tail fan, consisting of uropods and telson (Fig. 1.3), which enables the swift backward escape response (Cobb and Wang, 1985).

1.2.3 **Adult Habitat**

The spiny lobster is a shallow water species (Fig. 1.1) and has particular preference for coral and rocky reefs that are washed by sandy surfs. They inhabit mostly clear waters and prefer areas where the seabed is rocky and covered by macro-algae (Phillips et al., 2000). This near-shore habitat is very accessible to coastal fishermen.

1.2.4 **Feeding behaviour**

Spiny lobsters are active at night and are best described as omnivorous scavengers. They are major predators on various benthic species, including snails, clams and sea urchins (Phillips et al., 2000). Adults may show a food preference for mussels, whilst juveniles feed mostly on barnacles (Phillips and Kittaka, 2000).

Spiny lobsters are in turn important prey for larger ocean predators, including sharks and carnivorous fish species. It has also been reported that octopi take significant numbers of spiny lobsters from traps used in commercial fisheries (Zacharin, 1987; Brock and Ward, 2004).

1.3 ENVIRONMENTAL FACTORS AFFECTING LOBSTER FISHERIES

There are many possible reasons for failure of a fishery. Not all failures in marine fish stocks are due to fishing pressure. Environmental factors may play an equally important role in the state of fisheries (FAO, 1984). However, it requires in-depth research to establish whether the failure of the fishery is due to the natural phenomena, human impact or both. Both long and short-term changes in the environment may influence the abundance and distribution of spiny lobsters (Hilborn et al., 2003).

1.3.1 **Environmental effects on larvae**

Studies on stock and recruitment may reveal the relationship between puerulus settlement and breeding stock and the environmental factors influencing successful reproduction and settlement (Phillips and Brown, 1989). For effective management of fishery stocks, not only knowledge of recruitment processes, but also, the knowledge of physical, biological and environmental factors affecting the process is essential (Little, 1977). The length of the planktonic larval stages of many decapod crustaceans, including spiny lobsters, depends on the prevailing environmental conditions (Spicer and Eriksson, 2003, Linnane et al., 2000). Little (1997) gave a detailed account of the various environmental factors influencing recruitment processes for the *P. argus* in the Florida Keys.

As studies reveal, varying environmental conditions cause wide fluctuations in larval recruitment (e.g. puerulus settlement). Cobb & Caddy (1989) stated that environmental factors play a major role in determining spawning success and larval survival. The level of recruitment is related to levels of puerulus settlement, which in turn are linked to oceanographic processes such as ocean currents, as seen in Australia and Torres Strait in Papua (CSIRO, 2003). CSIRO scientists further state that habitat changes cause

variations in lobster populations. Freshwater river discharges could affect the survival of lobsters because they are sensitive to low salinity (Phillips and Sastry, 1980). In 1992 and 1999 many lobsters were starved to death in Papua New Guinea as floods flushed turbid freshwater into the lobster habitat causing large sea grass dieback. When the sea grass died, many of the invertebrates on which lobsters feed also disappeared leading to lobster mortality.

The relationships between seasonal migration and distribution of adult lobsters, larval recruitment processes and oceanographic features are mostly unclear (Campbell, 1989). There is a high correlation between larval supply and juvenile abundance, provided shelter is not limiting (Frusher et al, 2000). About half of the variation in puerulus settlement is due to environmental factors (Phillips and Brown, 1989). These authors further revealed that links between the environment and the lobster fisheries may have important implications particularly under conditions of long-term climate change. Subsequent years of poor environmental conditions can reduce the level of recruits to the fishery and hence the size of the subsequent breeding stock (Caputi et al, 2000). In Western Australia, the quantity and distribution of larval settlement appears to be dependent on the strength of the Leeuwin current that aids the transport of early phyllosoma larvae to far off distances (Wallace et al, 1998).

Environmental factors that may impact the survival of lobsters include water quality, habitat conditions, upwelling, harmful algal blooms and diseases.

1.3.2 **Water quality**

Instances of lobster mortalities have been reported in association with low-oxygen concentrations and elevated levels of sediment-derived toxicants (Valente and Cuomo, 2001). However, this study did not confirm these events as the direct cause of mass mortalities which have been a regular phenomena for decades in Long Island Sound region, during summers and early fall. It was further revealed that these mortalities could have occurred due to the convergence of several environmental factors that stressed the animals to make them vulnerable to opportunistic pathogens (Wilson et al., 2001).

Frequent irregular algal blooms occur in Omani coastal waters (Claereboudt et al., 2001). These are an annual phenomenon influenced by upwelling and other meteorological conditions (Steidinger, 1975). Although environmental conditions can impact lobster stocks, for this to happen there needs to be a change in these environmental conditions over the period of stock decline (Stewart Frusher, pers. com). The Florida Fish and Wildlife Institute (Anon[2], 2005) reported an outbreak of mass mortalities of fish in the Gulf of Mexico linked to red tide phenomenon during the first week of August 2005. Preliminary results showed anoxic (no oxygen) and hypoxic (low oxygen) conditions on the Gulf seabed.

Instances of mass mortalities of fish were recorded along the Oman coast in August 2000 (Claereboudt et al, 2001) and more recently in October 2005 (Anon[3], 2005), but lobsters were never recorded among the species affected.

1.3.3 **Diseases**

Diseases in natural lobster populations have rarely been recorded and the few reports available are from studies on clawed lobsters, *Homarus spp.* In 1999, massive mortalities of lobsters were observed in Long Island Sound possibly due to shell disease, the cause of which is not known (Tucker et al, 2001). Similar unexplained outbreaks occurred in Gulf of Maine, Massachusetts coast and New York Bright (Castro et al., 2001). Norwegian lobsters exposed to toxic dinoflagellate *Hematodinium sp.* have shown reduced swimming response and became vulnerable to trawler catch and predation (Stentiford et al, 2000). Tayler et al (1996) revealed that lobsters from the west coast of Scotland are known to harbour an infection of this parasitic dinoflagellate and the infected lobsters showed higher oxygen consumption than uninfected lobsters.

1.3.4 **Growth and reproduction**

There is evidence suggesting that the rates of growth and reproduction in spiny lobsters depend on the availability of food and hence may be density dependent (Caddy, 1990). The influence of environmental factors on size at maturity has been documented and negative growth (shrinkage) can significantly reduce size at maturity. For example

reduced or negative growth has been associated with environmental disturbance during El Nino years (Pollock et al, 1997).

In Oman Mohan (1997) stated that size at maturity is less in warmer, coral habitats compared with cooler habitats with dense strands of macro algae. Mohan (1997) also stated that the variation in size structure and size at maturity of *P. homarus* in different regions of Oman resulted from differences in environmental conditions. He further stated that the size and reproductive variation of lobsters at different sites along the Dhofar coast could be caused by growth-rate differences after larval recruitment that arise from different environmental conditions at the sites.

There is no scientific evidence for determining whether density dependent or independent factors, apart from availability of suitable habitat, influence numbers of planktonic larvae and juveniles recruiting into the fishery (Phillips and Kittaka, 2000). A spiny lobster population exposed to external (environmental) influences may gradually undergo changes in its genetic structure and its life history patterns (Garrod and Knights 1979). For example, lobsters have the ability to prolong their planktonic larval phase if a suitable habitat is absent or the environmental conditions are not favourable (Linnane et al., 2000).

1.4 LOBSTER FISHERIES MANAGEMENT

In lobster fisheries, scientists take into account a range of factors including fecundity, recruitment, growth rates, catch per unit fishing effort and fishing mortality to arrive at management strategies (Miller, 2003). At the early stages of development of a fishery, an increase in fishing effort results in a corresponding increase in the annual catch or yield. At this stage, catch rates will be high, encouraging more fishermen into the fishery. As the fishing effort continues to grow catch rate will decrease accordingly and is called the Catch Per Unit Effort (CPUE) (King, 1995). Eventually a level of fishing effort will be reached when further increases will no longer produce an increase in yield. This is the level of fishing effort that is required to secure maximum sustainable yield (MSY). King

(1995) describes MSY as the largest annual catch that may be taken from a stock continuously without affecting the catch of future years.

Generally, fisheries management is approached by understanding the mechanisms of larval settlements, its relationship with population dynamics and ultimate optimum sustained yields of adult stocks (Little and Milano, 1980). Hence, thorough knowledge of population dynamics is essential for effective management of fishery stocks because levels of recruitment to fishery stocks often result from the survival of juveniles (Little, 1977).

Fishery management measures range from individual regulations based on practical reasoning to comprehensive management policies involving in-depth studies of population dynamics of the species with a view to some quantitative model to describe the fishery (Hancock, 1980). The chosen management approach will be largely determined by the relative importance and value of the fishery. Regulations may have their origins in sociological, practical, economic and political as well as biological considerations. For example, minimum size regulation, introduced in Western Australia in 1897, is close to the average size at first maturity. It appears that the size regulation established years ago was based on practical knowledge rather than detailed scientific study (Morgan, 1980).

1.4.1 **General management issues**

Management measures are generally aimed at maximizing reproduction and limiting/regulating fishing effort. These measures include a minimum legal size limit and the prohibition of landing gravid females. Considerable attention is now being focused on issues like quota or limitation on the number of traps that each fisherman can have in the water and a limit on the number of lobsters that can be harvested commercially (Hancock, 1980). For example, the Nova Scotia lobster fishery[1] follows the following management measures to increase egg production (Miller, 2003). Although these

[1] Cold water lobsters different from palinurids.

practices were developed for American lobsters *Homarus americanus*, they can also be applied to other lobster species.

- Release of ovigerous females
- Tail notching ovigerous females so that they cannot be taken even if nonovigerous
- A maximum legal size to protect larger females
- A maximum trap entrance size to exclude larger lobsters
- Increased minimum legal size to permit more lobsters to spawn before their catch

In Australia, the focus is on quota management that limits fishing effort besides the regulatory measures mentioned above (Montgomery et al., 1996). They further stated that with the introduction of limited access in 1992 and total allowable commercial catch (TACC) in 1994, the fishery has noticed a positive change. In recent years, fishery management measures focused on use of fishery exclusion zones (FEZ) or closed areas (Smith and Jensen, 2006). Closing an area to fishing is expected to result in both increased biomass and improve average size class of mature animals within the protected zone.

Current research on lobster conservation has focused on whether the egg production from the female population is sufficient to maintain the stocks. These studies include 'recruitment overfishing' (Section 1.4.2) and 'growth overfishing' (Section 1.4.3) and their critical role in maintaining egg production. The following sections describe the above principles and their direct impact on the lobster reproduction.

1.4.2 **Recruitment Overfishing**

Recruitment overfishing describes a level of fishing activity at which the adult stock is reduced to the extent that recruits produced are insufficient to maintain the required population (King, 1995). A lobster resource can be considered overfished when it is harvested at a rate that results in egg production from the resource, on an egg-per-recruit basis, that is less than 25% of the level produced by a nonfished population (Anon[4], 2001). The American Lobster Fisheries Management Plan[2] recognises recruitment

[2] http://www.st.nmfs.gov/st2/methrev.html accessed on 28/02/2006

overfishing when the fishing mortality rate (F) results in a reduction in estimated egg production per recruit to 10 % or less of a non-fished population.

The average female lobster should be allowed to live long enough to produce at least 25% of eggs that the lobster would produce if she lived her natural life. It may be impossible to judge the egg production from a nonfished population, since the lobsters have been fished for many years. However, it should be easier to calculate the fecundity of a female that lived its natural life as specific biological parameters, such as how often a female produces eggs, how many eggs it spawns each time and longevity of a female are well known from studies of palinurid species in other fisheries.

Overfishing often refers to depleted stocks. Stock depletion and stock collapse are caused by recruitment overfishing, such that the adult population is fished so heavily that it does not have the reproductive capacity to replenish itself. Even if lobster recruitment is good, scientists are still concerned about the risks of recruitment overfishing[3].

The relationships between stock and recruitment and estimations of natural mortality have proved to be one of the most difficult to quantify. Therefore, one of the most difficult tasks is to win support, particularly from fishermen, about the benefits of protecting breeding stocks.

1.4.3 **Growth Overfishing**

Growth overfishing refers to a level of fishing in which young recruits entering the fishery are caught before they grow to an optimum marketable size (King, 1995). Growth overfishing occurs when animals are harvested at an average size that is smaller than the size that would produce the maximum yield per recruit. Simply stated, growth overfishing refers to the fishing of potential breeding stock. The total yield from the

[3] http://www.lobsterconservation.com/overfishing/ accessed on 17/03/2005

fishery would be better if the Fishing Mortality Rate, or percentages of the stock removed each year, were lower[4].

McGoodwin (1990) describes growth overfishing as one of the main conservation problems and defines it as 'a level of fishing effort so high that mostly smaller, younger animals are caught'. This is more common than recruitment overfishing, but it does not receive the same attention as recruitment overfishing because it does not pose such a serious threat to the continued existence of the resource. But growth overfishing still reduces the potential yield from a fishery and thus the economic and other benefits that could be obtained from the stock.

1.4.4 **Fishing Mortality Rate**

The term Fishing Mortality Rate (F) refers to the instantaneous rate at which animals are removed from the population by fishing. In a lobster fishery the F refers primarily to lobsters that are actually landed in the catch and not those which are returned to the sea and later die[5].

Of fundamental concern to fisheries authorities is the need to ensure that levels of exploitation will not result in recruitment overfishing. Worldwide, management strategies are aimed at maximizing egg production as well as increasing the survival of pre-recruits (Brown and Caputi, 1986). These measures aim at maintaining breeding stocks at or above historic levels, which have provided adequate recruitment in the past.

1.4.5. **Potential for high exploitation rates**

The exploitation rate depends on a number of factors such as, fishing effort, development of a market, capital cost of entry to the fishery, distribution of the lobster population and the vulnerability of the lobsters to capture. All these factors can collectively interact to produce a high exploitation rate (Hancock, 1980). The exploitation rate is the rate at which the legal (and sometimes illegal) size animals are harvested. In a well managed

[4] http://www.lobsterconservation.com/growthoverfishing/ accessed on 17/03/2005
[5] http://www.lobsterconservation.com/fishingmortalityrates/ accessed on 17/03/2005

fishery the number of lobsters exploited should, on average, be no greater than the number recruiting to the legal sized population.

1.4.6 **Markets**

Worldwide, the market price for lobsters has tended to rise in response to demand rather than the costs involved in the production (capture and processing). For example, the price paid to Omani fishermen has risen significantly over the years due to the competition for the product from traders and processing companies (A.N. Kumar[6], pers. com). The prices paid to fishermen increased from OR[7] 0.5/kg in 1980 to 4.8/kg in 2006. In Australia, the prices for lobsters have risen from A$[8] 0.84/kg in 1962 to more than A$ 15/kg in 1985 (Phillips and Brown, 1989). The average price of lobsters to fishermen this year has been A$ 26.50/kg (Theo Kailis, pers. com[9]).

1.4.7 **Capital Cost of Entry to Fishing**

Spiny lobsters are generally taken in shallow inshore waters, so that the capital required to enter the fishery may be limited to the cost of a small boat and traps/nets. This allows the fishermen an easy entry to the fishery and they are able to recover the additional costs quickly without any great financial risk (Fonteles-Filho, 2000). This situation is true for Oman. In more industrialised fisheries, such as are found in Australia, the cost of entry is considerable. There fisherman must invest in high-powered boats and GPS assisted fishing equipment and must also purchase expensive licenses (Philips et al., 2000).

1.4.8 **Distribution of Lobster Populations**

In many countries, lobsters are not only located close to the shoreline, but they are also concentrated in a few places (Bowen, 1980). Consequently fishermen are able to centre their activities in these few places and exploit the lobster population to its maximum.

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[6] Marketing Department, Oman Fisheries Co. SAOG
[7] 1 OR = 2.58 US $ March 2006
[8] 1A$ = 0.73 US $ March 2006
[9] Kailis & France Foods, Perth, Western Australia.

This is particularly true in countries like Oman, Yemen and Somalia where lobster fishing is restricted to shallow inshore waters where fishing is an easy task (Fielding and Mann, 1999).

1.4.9 **Vulnerability of Lobsters to Capture**

Research has shown that the volume of lobsters landed is influenced by the type of bait used, the sea swell, wind strength, tidal movement and water turbidity. Over longer periods, landings are influenced by lunar cycles, water temperature, salinity and the percentage of lobsters in premoult condition (Morgan, 1974).

Vulnerability generally decreases with an increase in size (Cobb and Phillips, 1980). In spite of this, the lobster traps and nets are very effective as catching methods to generate a high exploitation rate of legal-sized lobsters (Morgan 1977).

1.5 COMMON RESOURCE ISSUES

In carrying out management of a common resource, governments must ensure that the basis for sharing the resource among all users is clearly understood and accepted and that allocation of fisheries resources and their level of utilization are consistent with the needs of present and future generations (Zacharin, 1997). As global spiny lobster fisheries developed in the 1950s and 1960s, populations declined, forcing administrators to look into strategies to protect stocks.

Several basic principles were initially emphasised. In the Western Australia spiny lobster fishery Hancock (1980) identified the following:

- Optimum utilization of the resource
- Reasonable economic return
- Orderly fishing

This fishery remains the leading example of a well-managed spiny lobster fishery where management policies, combined with strict enforcement, have resulted in catches

of over 11,000 tons each year (Phillips et al., 2000; Hilborn et al., 2003) for nearly a decade. The Marine Stewardship Council (UK) in the year 2000 has accredited the western Australian rock lobster fishery as environmentally and commercially sustainable. This was the first such accredited lobster fishery.

1.5.1 **Optimum Utilization of the Resource**

Optimum catch is that which would be achieved by allowing the animals to reach their greatest total weight and then catching them, so that by then they would have spawned at least once (Beverton and Holt, 1993). The aim is to promote maximum production from the fishery in the long term while maintaining sufficient stocks in the wild. This should be clearly communicated and understood by the fishermen so that they can appreciate the consequences of over fishing and the long-term impact of their own activities. With this basic knowledge, it is hoped that they will accept additional conservation measures (Bowen, 1980).

1.5.2 **Reasonable Economic Return**

In the short term, implementing restrictive management controls will mean lower incomes to the fishermen. This may need to be addressed by the respective governments. Lobster fishing, in general, is restricted to only a few selective coastal locations, which might allow the governments to provide support during periods of enforced conservation measures. This may even include temporary financial compensation and other forms of social welfare assistance. In the longer term, properly enforced conservation measures should start to positively impact the fishery, ensuring the socio-economic independence of fishermen for future generations.

1.5.3 **Orderly Fishing**

Operating in a common resource like a capture fishery can create difficulties for the participants due to the variation in efficiencies between different fishermen (Bowen, 1980). In these circumstances, fishermen generally might expect from the Government,

rules that will reduce conflicts arising from a concentration of boats and traps on preferred fishing grounds dominated by wealthy and influential fishermen. Regulations might relate to the number of traps operated by each fisherman but strict surveillance measures are required to ensure compliance.

1.6 SUSTAINABILITY

Sustainable fisheries are the objective and responsibility of many maritime countries through the protection of valuable fishery resources for the well being of their present and future fishing industry (Zacharin, 1997). Its complexity may depend on the extent of the fishery itself as countries with long coastlines and diversified fishery resources have far more problems than smaller countries. Experience has shown that where there is unrestricted use of marine resources, there is little incentive for individuals harvesting the resource to conserve fish stocks and competition amongst users often leads to resource depletion (Zacharin, 1997).

Fisheries management objectives may include economic, social and environmental objectives apart from conservation of fish stocks (King, 1995). The formulation of management decisions must be made on the basis of reliable data and research on the biological, environmental, economic and social aspects of the fisheries (FAO, 1984). There are four main issues that fishery managers must consider when deciding which management measures to apply:

1. Biological consequences
2. Economic consequences
3. Social consequences
4. Administrative consequences

1.6.1 **Biological Consequences**

Accurate data that describes both the fishery and markets relevant to the fishery are important components in its effective management. Policy makers should have before them three sets of basic figures:

- best current estimates of potential sustainable yield from the stock
- present catch levels
- plans for increases in the catch

It is necessary that biologists, economists and administrators are then required to interact with each other to understand the respective objectives, the data required and finally the manner in which the data should be integrated to provide for an effective management strategy. As a consequence of biological research outcomes, the management measures can be undertaken in the form of size limits, gear restrictions, catch targets, closed areas and seasons etc (Rogers, 2002).

1.6.2 **Economic Consequences**

Although economic research need not be a continuing process, periodic surveys have to be undertaken to gain an understanding of the economic consequences of the regulations imposed on the fishery. This should also be performed before any actual regulatory measures are imposed to gain a feeling of what will be the economic consequences if the conservative measures are imposed.

In general, economic consequences include changes in net economic benefits to harvesters, processors, distributors, marketers and consumers. The net benefits are related to landings (amounts and seasonal patterns); fishing patterns; harvesting capacity; harvesting practices (fishing techniques, product handling); by catch; product utilization (discard rate, grading); landed product forms; harvesting costs; gear conflicts; gear loss; employment in harvesting and processing; safety; sales/revenues etc. In the market sector, net benefits are related to prices (levels and seasonal patterns), product quality and forms, product utilization, product availability patterns, imports and exports, and consumption patterns.

The management plans should be designed and implemented in such a way that the plan offers the most favourable economic consequences to all those who associate in the lobster fishery. One should also expect growth in net incomes over time when stock

conditions improve. Provisions such as permission to sell their own fishing licenses (in case of any restriction imposed earlier as a control measure – limited entry to fishing) may provide economic benefits to the fishermen. These ideas make good sense, particularly when adequate stocks are rebuilt and a percentage of fishermen are willing to retire due to age, health reasons or personal circumstances (Evaluation of lobster management plans, Dept. of Natural Resource Economics, University of Rhode Island[10]).

Implementing such measures may prove beneficial to Oman, but may have to be done at a later stage in the management plan due to the current open access system that allows any Omani entry into the fishery by paying a token licence fee. Restricting entry to fishing might be problematic and needs to be done in a step by step manner.

1.6.3 **Social Consequences**

1.6.3.1 Common Property Resources and Game Theory

The question of how collective action might improve or worsen resource allocation generally was explored by Olson (1965). Game theory, or the theory of interdependent decision-making is a component of the economics of collective action, to study fisheries problems has become well known through the work of Elinor Ostrom (1990). She demonstrated how different strucutures of rules, payoffs and decision sequences can produce different outcomes for interdependent users of natural resources. Munro (2006) noted that "it is all but impossible to analyse the economics of the management of fishery resources other than through the lens of game theory".

Baland and Platteau (1996) presented a similar argument to Ostrom (1990). These authors elucidate the conditions under which the setting and the incentive structure of users of natural resources can actually support rational systems for appropriating the resource and for investing in it. Palfreman (1999) describes game theory as originally a branch of applied mathematics that studies how people and businesses make decisions

[10] http://www.ci.uri.edu/projects/rifish/documents/education_lobster_mgt_Plans.htm accessed on 18/03/2005

when they are mutually interdependent. The resource user does not for sure what the outcome of his strategy in the game is going to be, because that depends on the strategy of others in the game. The fish industry includes many situations where individual businesses are interdependent and face the choice of whether to compete or collaborate, or a mixture of the two. Al-Oufi et al (2000) identified some in Oman.

The key question for fisheries is the transformation of actual or potential "prisoner's dilemmas"[11] into more constructive, collaborative arrangements. Palfreman (1999) suggests that four fundamental issues need to be addressed if the insights from game theory are to be put into practice.

First, the rules of the game have to be known by the participants if the collaboration is going to be sustainable. These rules do not need to be explicit legislation, as Ostrom (1990) points out. These rules need: (a) some form of explicit or cultural exclusion mechanism if resource rents are going to be realized – thus an "open access free-for all" can become common property, which, with explicit support from the Ministry, can evolve towards a managed fishery; (b) provisions for resource appropriation; (c) provisions for contributions to be made by participants.

Second, because collective gains can arise in a variety of different ways so the economics of collective action requires the benefit delivery mechanism to be explicit. Lobster fishermen will not conform to decisions on fisheries management on the strength of vague promises of some gains in the future which might (or might not) accrue to them. They will want to know with some precision how a new rule might deliver benefits to them as individual businesses.

The third key element is the magintude of the expected benefits. Small gains, or benefits which are expected to accrue in the distant future are not likely to induce much enthusiasm among potential participants.

[11] The "prisoner's dilemma" is whether or not to incriminate a partner in a particular crime, when he is offered an incentive to do so (such as a shorter prision sentence) and he does not know whether or not his partner has incriminated him.

The fourth issue concerns risk and uncretainty. Expected gains from collective action may be substantial but if outcomes are uncertain they lose their value to participants, especially if the time horizons of participants are short.

Attention to these four ingredients can turn round a "prisoner's dilemma" into the possibility of long term sustainability.

How do these 4 basic design suggestions translate into practical recommendations for Oman lobster fisheries?

(1) In the locations studies the fishing community is already accustomed to working together, so may have implicit rules. Examples include having implicit or explicit agreements on taking turns to use good fishing spots, or landing in a certain order, or cooperating on purchasing inputs. In small-scale and remote communities, the collaboration between fishermen can extend into other social and economic sectors. These can supply the basis for establishing rules for resource and market management systems. Equally, for fisheries managers, it is important for these formal or informal structures to be elucidated, adapted to the circumstances and supported by the Ministry.
(2) Information is fundamental. It enables fishermen to assess the benefits of cooperating in a collective endeavour or, alternatively, going their own individual way. The more good quality cost and benefit information flowing back to fishermen the better. The fish processing sector in Oman might be of assistance here.
(3) The clarity of the definition of the resources prosecuted is helpful – a condition which is broadly met in this case. It is easier for people to assess the pay-off structure if the resource is well defined. The technical capability of the Ministry can contribute to this area.
(4) This kind of shared responsibility can be encouraged if someone assumes a leadership role because this helps to reinforce the rules. This condition is met in Oman through traditional tribal structures.

(5) The presence of member specific or localised benefits is supportive of cooperation. Those who reap the greatest benefits resulting from collective efforts may be willing to subsidise (possible implicitly) others from their own gains to persuade them to conform. Thus they are prepared to make "side payments" to encourage collective action.

The spiny lobster fishery (*Panulirus argus*) of the Punto Allen, Mexico is a good expample of community based management system where well organized co-operative and exclusive access to the fishing lots (where artificial reefs were implemented) to members have lead to successful and long-term benefits (Castilla and Defeo, 2001). Fishers have also participated in, and directly benefited from, research efforts related to geographic specification of fishing lots and estimates of fishery yield.

Studying marine resource-dependent communities is a priority when dealing with fishery management plans. The case for arrangements whereby there is mobility into and out of the lobster fishery is made in http://www.ci.uri.edu. It is argued that this is likely to offer more favourable social consequences in the longer term (in case entry to fishing was restricted in the short term in order to rebuild the stocks). This may eventually encourage a stronger sense of cooperation among the wider fishing community and the adverse impact of specific fisheries management measures on the local lobster-fishing community might be allowed.

It may be essential that any fishery management plan first attempts to conserve the stocks for a certain period, ensuring adequate stocks are rebuilt and only then permit increased access granted in a gradual step-by-step manner. Once implemented, an open acess plan may be perceived as fair among many fishermen and other community members. No privileged class of lobster fishermen is created and there are no "haves" and "have-nots". All who want to enter the fishery may do so, and they compete on equal terms with others in the fishery. However, if the open access is perceived a threat for the sustainability of resoures or if the fishermen do not support the measure as the value of their license will be reduced, then fisheries management measures, including an

exclusion mechanism and a quota system might have to be introduced by the state. However, recalling the lessons from game theory, a more flexible management system, constructed around, or evolved from, local customs, practices, implicit exclusion mechanisms and unspoken "rules of the game"might be feasible.

However, management of Common Property Resources (CPR) is easier said than done since it is a very complex and sensitive issue. Several attempts have been made focusing on CPR and Hardin's (1968) Tragedy of the Commons is a noteworthy counter-argument to the proponents of local control of resources. It suggests that if lobster fisheries management is going to be sustainable the state will have to play a more active, albeit sensitive, role in sustaining the fishery.

1.6.4 **Administrative Consequences**

Administrative consequences include changes in the amount of enforcement resources and associated costs; compliance and enforcement problems; industry acceptance and cooperation or resistance; information demands; costs of monitoring resources and research requirements; costs of data collection and data degradation including miss reporting of landings and fishing activities. Administrative consequences also include the extent to which lobster fishermen encourage their representatives to become involved in the implementation of management measures. Such influences are well known for their tendency to thwart the ability of fishery management authorities to effectively manage the fisheries for which they are responsible (http://www.ci.uri.edu).

Administration of common resources such as fisheries does pose some difficulties, since strict enforcement creates significant costs to the authorities. Reducing fishing effort to increase egg production or significantly impact the fishing mortality would be opposed by the fishers (Miller, 2003). In these circumstances, a new management plan needs strong support, especially from the fishermen.

The administration, during the initial stages of the management plan faces rising costs on one side and resistance from the other. Apart from costs incurred on research, data collection and establishing conservation measures, the authorities need funds to communicate the importance of such measures to the fishermen and educate them as to why such measures are required. As will be emphasised through out this research study, *it is very important that any fishery management plan requires support from its main stakeholders, that is the fishermen. Without their active participation and their wholehearted support, any management plan is likely to fail.*

It is a fact that effective administration and enforcement means a substantial cost to the administrative authority. But it should be perceived, as a social and economical investment in the interest of the nation and no government, including Oman, should have reservations over such an approach. In the long term, a well managed industry should become self-financing through increased production and tax revenues which can support management costs.

Some of the best examples are the various Australian (Victorian, Tasmanian, and South Australian) Cuban and the Rhode Island (USA) lobster fishery management plans. The respective administrations initially spent substantial sums on research and data collection before arriving at a comprehensive management plan. They continue to incur costs on research, surveillance and enforcement (although most of these costs are recovered from the industry participants) but the efforts have resulted in a much-improved industry compared to previous years when management was poor.

1.6.5 **Management of lobster fisheries in Oman**

There is no comprehensive management plan in place for any sector of the Oman fishery, although some measures are being implemented to regulate the fishery. Rogers (2002) suggested certain management measures for the management of lobster fishery in Oman. However, they are yet to be implemented. After collaborative studies with FAO (1979) and Omani – American Joint Commission for Economic and Technical Cooperation (RDA, 1988, 1990), the government implemented some basic measures as a reactive

approach to solve the problem of lobster fishery decline. These measures are discussed in Chapter 2.

1.7 ENHANCEMENT TECHNIQUES FOR LOBSTER FISHERIES

Productivity from many of the world's marine capture fisheries has decreased and many shellfish stocks no longer provide yields close to their sustainable potential (Edwards, 2005). Fishery managers and scientists have highlighted the scope for rebuilding many depleted stocks by adopting programmes to release cultured larvae and/or juveniles into the wild. Worldwide lobster stock management plans have focused on measures to foster better control of existing populations and to complement these actions with the enhancement of lobster populations through the release of cultured phyllosoma larvae, pueruli or juveniles. Enhancement may also involve the development of suitable habitat or provision of artificial shelters in release areas. To be successful, lobster stock enhancement programmes depend on reliable information on the ecology and life cycle of lobsters if this approach is to assist with improved fisheries management (Kanciruk, 1980).

This section presents an overview of both the earlier attempts in understanding the life cycle of lobster species for stock enhancement programmes and current practices. The focus of this review is spiny lobster stock enhancement. Reference is also made to culture and enhancement programmes for clawed lobsters (*Homarus sp.*), which are generally at a more advanced stage of development.

1.7.1 **Culture of spiny lobsters**

Culture techniques can be applied in a variety of ways for the enhancement of lobster fisheries. These were summarised by Mohan (2001):

- Holding and conditioning of damaged or undersize lobsters prior to sale.
- Holding commercial-sized lobsters in order to meet favourable market demand.
- Short term holding prior to live transport to distant markets.

- Harvest of pueruli or juvenile lobsters from the wild for growing to commercial size in aquaculture facilities.
- Larval rearing from eggs to pueruli for re-seeding and enhancement.

1.7.1.1 *Holding and fattening*

This is the common method of culturing lobsters, as the culture period from egg to harvest size is too long for commercial applications. This method involves holding undersized or low-valued (soft shelled, damaged) lobsters for one or two moults to increase the size and value of the lobsters. This can be achieved by holding them in land based tanks or sea cages and fed with natural and artificial diet. Lellis (1990) reported 60% return of investment in an experiment with *Panulirus argus* in Florida. He further stated that these lobsters with an average size of 300 – 400g moulted every 50 – 60 days with an average size increment of 40%. In India, NIOT[12] (Anon[5], 2004) initiated lobster cage culture project involving the same principle.

There is also potential for utilizing wild pueruli for ongrowing to marketable size although there is increasing concern for this method. Pueruli collectors have been used successfully to catch the pueruli for different purposes (Phillips and Booth, 1994). Mohan (2001) listed a number of methods and their efficiency for collecting pueruli from wild. Although there is potential for these methods, the sustainability of wild resources is a major concern to address.

1.7.1.2 *Lobster propagation*

Lobster propagation, where the complete life cycle is controlled, is a management tool that could contribute to the sustainable restoration of lobster fisheries without impacting the wild stocks (Anon[6], 2000). However, closing the life cycle in spiny lobsters has proven to be very difficult. Only three countries – Japan, New Zealand and Australia have been able to complete the larval phase in captivity (Anon[6], 2000). The problem lies in the very long larval stage (9-24 months). Of the larvae that have survived to puerulus

[12] National Institute of Ocean Technology, Chennai, India

in culture, very few have survived to the juvenile stage and additional research is required (Kittaka and Booth, 2001).

As the commercial harvest of pueruli and juveniles has serious implications on long term sustainability of wild resources, a cost effective hatchery production of phyllosoma and pueruli is necessary for both enhancement and commercial farming purposes. Significant advances have been made in recent years in the larval rearing both in terms of survival rates as well as reducing the larval development period (Buxton, 2005).

1.7.2 **Stock enhancement**

Production of phyllosoma larvae, pueruli or juveniles and their subsequent release into the sea may constitute a practical method of increasing lobster resources. It also provides valuable material for the study of the early life cycle of lobsters (Nonaka et al. 2000).

Stock enhancement may be achieved by addition of animals to depleted areas of seabed (Mohan, pers.com). This assumes that the carrying capacity of the habitat is unaltered and would support an increased number of lobsters (i.e. sufficient density of prey etc). Enhancement can also be achieved by increasing the available habitat (Sosa-Cordero et al, 1998).

It is generally considered that many puerulus do not find suitable habitat and die due to increased exposure to predation (Gonzalez, 2003). Increasing the area of available habitat could therefore improve survival of juvenile lobsters that would later enter the commercial fishery (Anon[7], 2003). However, as suggested by Al-Hafidh (1999) in relation to the Oman abalone fishery, it is necessary to carry out a detailed ecological study before releasing the larvae in the wild. Only then the stock will be maintained and the future of the fishery will be assured.

Studies have shown that there is a high level of density dependence between puerulus settlement and subsequent catches (Caputi et al., 1995). Research also reveals that there is a very high mortality between the time pueruli settle in the coastal reefs and the time

lobsters move offshore and recruit into the fishery (Phillips et al., 2003). Even if the volumes of post larvae released into the sea are actually very high, only a fraction will reach maturity to have any kind of impact on the fishery.

As lobsters have a complicated life cycle, phyllosoma larvae released in the sea take up to 24 months to undergo 11 – 13 moults before settling on the reef. The natural mortality in the first year itself approaches 97% (Phillips et al. 2003). Independent estimates of survival on mark-recapture of micro wire tagged animals were similar, with a survival range between 0.64 and 4.1%. It is clear therefore, the number of phyllosoma larvae required to have a significant impact on the fishery is huge compared with the number of sub-adults released into sea (Beal et al., 2002).

The stage at which juvenile lobsters are released to the fishery significantly impacts both the cost and effectiveness of the restoration programme (Beal et al., 2002). Therefore, stock enhancement programmes focus on different strategies to overcome the constraints in the natural environment at different stages (larvae, pueruli, juveniles) to improve their survival rates in the wild (Beal et al., 2001).

Research on culture techniques for spiny lobsters began as early as 1899 in Japan, with the experimental hatching and rearing of phyllosoma (Nonaka et al. 2000). One hundred years later Kittaka (1989) reported success in completing the development of larval stages up to puerulus stage in *Panulirus japonicus.*

Most research has focussed on methods to improve the survival rates of cultured larvae. The main obstacle is the extremely long development period and the poorly understood requirements of the phyllosoma larvae (Van Olst *et al*, 1980). Recent studies at the Tasmanian Aquaculture Institute suggests that they have succeeded in reducing the larval development period from two years to just one year (Buxton, 2005). It is important that further research should focus on improving the survival rates of larvae. Buxton (2005) identified health as a key issue for future research.

As stated above, larval survival rate is the crucial limiting factor in lobster culture (Kittaka and Booth, 2000). Successful larval rearing to metamorphosis (post-larval and

juvenile stages) has been achieved by only a few institutions (Cobb and Phillips, 1980). As a result, large-scale larval culture of spiny lobsters has still not been achieved despite considerable advances in the understanding of their biology and life history. Table 1.2 shows the survival rates obtained for different species of lobsters at different laboratories up to stage IV or puerulus stage. These earlier experiments have mainly focused on refinement of hatchery technology (Cobb and Phillips, 1980) and improving survival rates of larval stages.

Table 1.2 A comparison of clawed and spiny lobster survival rates.

Year	Place of Experiment	Species	Survival Rate
2001[1]	North America	*Homarus americanus*	44%
2004	North America	*Homarus americanus*	50-60%
1996[2]	Shetland	*Homarus gammarus*	10% (77% after stage IV)
1991[3]	Japan	*Jasus vereauxi*	12.6% (234 days)
1998	Japan	*Jasus edwarsii*	88.6% (103 days)
1997[4]	New Zealand	*Jasus edwarsii*	40% (25 days)

Source: 1 – Beal (2004); 2 – Watt and Arthur (1996); 3 – Kittaka (2000); 4 – Tong and Moss (2000)

In spite of significant developments in lobster hatchery technology and grow-out techniques, there is little progress in the direction of commercial farming of spiny lobsters. This in large part is due to the fact that it takes up to 3 to 4 years or more under optimum conditions for spiny lobsters to reach commercial size from hatching. The culture methods practiced also often depend on wild sources of juveniles for on growing, a practice which could negatively impact the wild fishery (Phillips et al., 2003).

It has been suggested that since survival of pueruli in nature is low, then the removal of some pueruli for on growing could result in better production (Kittaka and Booth, 2000). In New Zealand, thousands of pueruli and juveniles are collected for commercial on growing by those retiring from commercial fishing in exchange of their fishing quota

(Anon[8], 2004). A different approach is being considered in Australia. This involves the return of cultured females to the wild to compensate for the removal of pueruli. Several spiny lobster species can be on grown from puerulus or juvenile stage to market size in 1 or 2 years time although many problems such as high costs, feed conversion and survival persist and still need to be addressed (Kittaka and Booth, 2000). They further state that in the long term pueruli cultured from eggs will be more acceptable and that will also lead to a more regular and predictable supply of stock.

1.7.3 **Additional Components of Stock Enhancement Programmes**

In addition to culture methods an integrated lobster stock enhancement programme must also involve an initial component involving a detailed study of the habitat in the proposed release area. Habitat modification involving the use of shelters may also be necessary to optimise survival rates. Survival rates of artificially stocked larvae or juveniles should also be monitored regularly, in order to assess the success of the program.

1.7.3.1 *Habitat and stock enhancement*

Increasing survival of larvae on the ocean bottom is a key component in stock enhancement initiatives. Good environmental conditions play a vital role in the settlement of puerulus in the habitat. Even with high levels of egg production, pueruli settlement will be lower if environmental conditions are not favourable and subsequently lead to a decline in the fishery (Caputi and Brown, 1989).

In general, lobster stock enhancement involves two major components: production of lobster larvae and habitat enhancement. However, more innovative approaches might change the ways that lobster stock enhancement is currently managed (Gonzalez, 2003): Implementing field-based cages containing lobster larvae either obtained by hatchery rearing, or directly from egg-bearing females kept inside the cages. The objective is to improve the survival rate of lobster individuals by allowing them to develop into more advanced stages (juveniles) in field based cages so reducing predation.

Watt and Arthur (1996) explained that in Shetland, stage IV larvae of the clawed lobster, *Homarus gammarus*, sink to the seabed where they burrow or seek shelters from predators. They remain out of sight until they reach 30 or 40mm size, when they emerge and adopt adult lobster lifecycle. At more advanced stages, lobsters are better able to locate shelters so increasing their survival chances (Gonzalez, 2003). A method of increasing yields from the fishery is to extend the fishing grounds by transplanting lobsters (pueruli or juveniles) to other geographical areas with suitable habitats (Van Olst et al, 1980; Mohan, pers.com).

Scientists have successfully developed technologies to improve the survival of larvae at the sea bottom. They claim the development of low-cost, low-maintenance field based nursery cages for rearing hatchery reared clawed lobster to Stage IV (Beal et al., 2002). This device allows individuals to survive and grow by suspension feeding on the plankton and/or foraging on the fouling biomass that develops on the cages. They showed that this system increases the larval survival in a cost-effective way and can be applied to other lobster species.

Cost effective production of lobster juveniles is not the only factor to consider for a successful stock enhancement programme. An adequate habitat enhancement programme aimed to optimize the habitat conditions in which lobsters are developing is essential. Habitat enhancement of lobsters, by means of providing artificial shelters has been successful for spiny lobsters in Cuba and Mexico (Sosa et al. 1998) and in Maine (Gonzalez, 2003). Conditions on coastal water bottoms are particular to each region and they have to be assessed to determine which habitat enhancement improvements are applicable. Innovative approaches have to be tested.

1.7.3.2 *Artificial Shelters*

One of the ways by which man responds to various factors that impair the productivity of the coastal ecosystems is the establishment of artificial reefs (Miclat & Miclat, 1989). These man-made structures, when submerged in the marine environment can provide shelter, food and breeding grounds for marine life. At the early stages of development,

the lobster larvae are an easy target for predators, since they are found in the seawater column and only seek shelter in later development stages. This phenomenon is an important drawback in lobster enhancement plans. Some scientists estimate the mortality for lobster larvae seeded into the sea is greater than 99%, but no firm data is available to confirm it (Gonzalez, 2003). Creation of artificial shelters may improve pueruli/juvenile survival on the seabed.

Careful consideration has to be applied to the nature of artificial habitat creation. Simply creating a collection of boulders on the seabed may be totally inappropriate to form an artificial reef specifically for lobsters. Lobster puerulus and post-puerulus prefer to live in small holes only slightly larger than their body sizes (Yoshimura and Yamakawa, 1988). If such holes are not available then this juvenile stage is unlikely to survive. Hence, habitat selection is an important criterion when dealing with enhancement tasks.

Physical characteristics of shelters are important as multiple openings and shaded cover could provide safe hiding for communal lobsters. In addition to these physical characteristics, local habitat features are also important in determining the success of artificial shelters in attracting and concentrating lobsters. Sites without or distant from habitats rich in lobster food should be avoided when placing artificial shelters (Sosa-Cordero et al, 1998).

It is well known that spiny lobsters gather in sunken ships. This follows their behaviour of sheltering in dark places during day time. Because of this, laying structures imitating lobster habitats may lead to the formation of fishing grounds (JRGFE, 1976). A major feature of the Cuban lobster fishery has been the introduction of the artificial shelters known as 'persqueros'. Similarly, the spiny lobster fishery in Mexico uses artificial shelters called 'casitas'.

However, the use of artificial reefs to increase fishery production remains controversial due to the hypothesis that the use of artificial shelters could lead to overexploitation of

the resource as they attract naturally dispersed animals to aggregate and thus increase vulnerability to capture (Phillips & Kittaka, 2000). Another important concern is that increased predation pressure at or near artificial reefs could outweigh the benefits of potential increases in production. Hence, a detailed ecological study should be undertaken before deciding to implement artificial shelters to augment lobster stocks.

1.7.3.3 *Evaluation of Enhancement Programmes*

Any stock enhancement programmes require continual field monitoring and evaluation. This approach provides feedback as to the status of the fishery so allowing informed decision-making processes relating to programme modification, the cost effectiveness of the programme or the requirement for additional management tools.

Adequate survey methodologies are critical to determine whether lobster stock enhancement programmes are successful or not. A vital tool in any stock enhancement programme is a reliable means of identifying animals on recapture. In lobster release studies (*Homarus* sp.), identification is made particularly difficult by moulting and by the small size of the juveniles (Linnane and Mercer, 1998). Hence, larval/juvenile tagging techniques that would allow the monitoring of lobster stock enhancement programmes have proven to be unreliable and only relative success has been attained when individuals larger than 15mm CL (Carapace Length) are tagged.

Although a number of tagging methods are practiced, only a few are reliable with regard to lobsters. Linnane and Mercer (1998) described the relative success of micro tags for small lobsters with just 8mm-carapace length. They reported both high survival (82 – 97%) and tag retention (97%) for micro tags among the study of 5 popular tagging methods – micro tags, visible implant elastomer, streamer tags, branding and rostrum ablation. Although feasible, micro tags are unsuited for stage IV or post larvae. Sharp *et al* (2000) reported tag retention of 86% for the first stage juveniles and 96% for second stage juveniles of *Panulirus argus.* Data obtained from these recaptured lobsters provide the first detailed estimates of growth of *P. argus* under natural conditions during the

earliest part of their benthic life and portray the usefulness of coded microwire tags in mark-recapture investigations of juveniles for this and other species.

Genetic tagging, perhaps the most advanced, is the determination of common hereditary information. This allows stock enhancement surveys without physically interfering with the lobsters prior to release and will provide common hereditary information identifying the source of lobsters that later enter the commercial fishery. This genetic tagging method requires a genetic characterization (fingerprint) of the female lobsters used as the progenitors (Gonzalez, 2003). This technique provides a measure of the success of lobster stock enhancement programmes.

1.7.4 Stock Enhancement: Potential in Oman

In this section the past approach to understanding the life cycle of lobsters was discussed. Attempts to enhance lobster stocks and enhancement programme methods are being undertaken currently have been reviewed. It was further emphasised that it was important to obtain larvae through lobster propagation rather than just relying on wild sources. Equally, consideration was given to habitat enhancement where lobster larvae and juveniles were released. In addition to stock enhancement, continual stock surveys and data analysis are critical for improving management programmes to achieve the desired targets. Only by securing a complete and secure database and when the cost effectiveness of different management tools has been properly evaluated can the fishery be managed effectively in the long term.

However in Oman, no study has been conducted towards this objective. Stock enhancement is crucial for the success of other management strategies being proposed in this study. The researcher believes that the first objective should be to increase the stock levels before effective and better management approach could take control of the situation. Initial steps will involve the gathering of essential biological information and an evaluation of the available habitats. To be successful, there is a need to collate available biological information and to evaluate the economic feasibility of lobster propagation in Oman.

SUMMARY

In this chapter, a review, based on the literature, was made of the general biology of spiny lobsters, their fishery management and stock assessment techniques. The review included most of the known, published work arising from studies conducted in Oman. The chapter also touched on some of the past and current status of stock enhancement and its prospects in Oman.

CHAPTER TWO

THE OMAN LOBSTER FISHERY

2.1 INTRODUCTION

Prior to 1970 lobsters were generally considered by Omani fishermen as a nuisance. They caused damage to fishing nets and these were difficult to repair, given the poor infrastructure found in most fishing villages. Travel was difficult to the major centers of Muscat and Salalah, necessitating trips of 20-30 hours to obtain new gear and supplies. Whilst Oman remained relatively isolated, fishermen were unaware of the commercial value of lobsters. Catches were incidental and the resource was abundant along the southern coast of Oman.

Under the new progressive regime of the 1970s, Oman opened its doors to the modern world and the country's valuable fishery resources were soon revealed. The lobster fishery was no exception. In the early 1980s, the government established the Oman National Fisheries Company (ONFC) to develop the fisheries sector. The company was formed as a joint stock company with 20% shares retained by the government, 20% shares assigned to fishermen and the remaining 60% to the private sector.

ONFC played a crucial role in the development of the lobster fishery in the Sultanate of Oman. During this period, interest in the lobster fishery continued to develop exponentially and it soon became a fully-fledged industry with fishing continuing throughout the year. There were times when ONFC would handle 60 MT/day during the peak season, although today the typical volume is just a few hundred kg/day.

ONFC entered into joint venture marketing arrangements with a Western Australian based company to export the lobsters under their brand name. Soon, ONFC's own brands (Al-Jazir, Taqa) were established to focus on markets in France and the USA. Sophisticated processing techniques coupled with aggressive marketing played a major role in commercializing Omani lobsters in international trade. This encouraged more fishing companies, traders, commission agents and fishermen to enter the lobster

industry, which generated significant profits. Eventually a 300-kilometre stretch of the Wusta and Dhofar coast, with a number of small fishing villages, became the centre of the lobster fishing activity with more and more players entering the trade.

This pattern of development reflected a common trend of increased fishing effort on a poorly understood and under-managed resource.

From a largely incidental fishery around Masirah Island (Fig. 1) in the early 1970s, the lobster fishery rapidly developed into a commercial fishery during the 1980s. Annual catches peaked in 1986 at 2122 MT (Al-Abdulsalaam, 1989) and then declined to the current level of 233 MT in 2004 (Figs. 2.1 and 2.2).

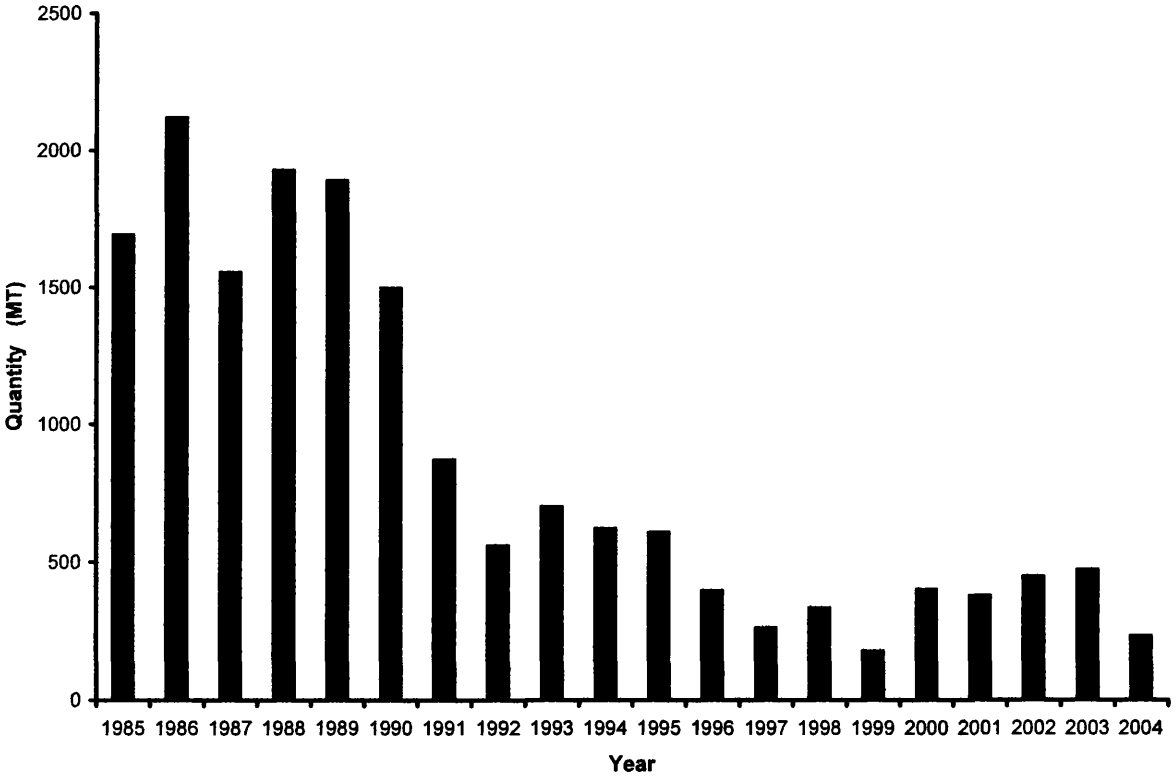


Fig. 2.1 Lobster landings in weight (MT)
(Source: Ministry of Agriculture and Fisheries, 2004)

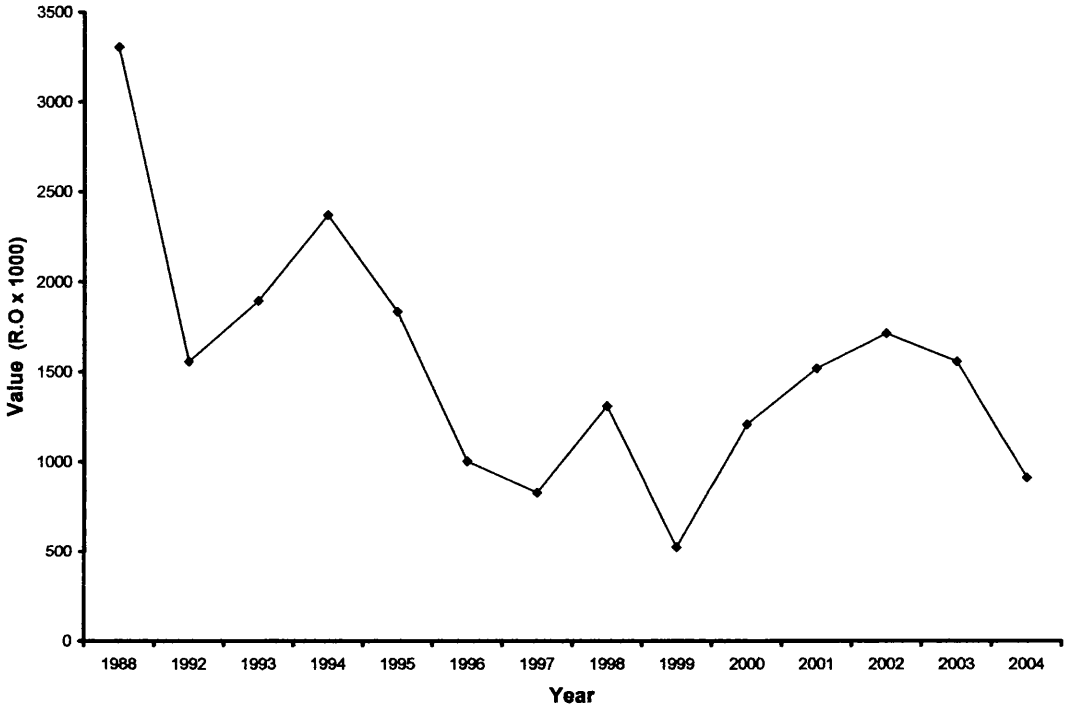


Fig. 2.2 The estimated value of spiny lobsters landed in Oman during the period 1988 - 2004
(Source: Ministry of Agriculture and Fisheries, 2004)

2.2 THE CURRENT STATUS OF THE OMAN LOBSTER FISHERY

During the fishing season, fishermen in the Al-Wusta and Dhofar regions exploit traditional grounds, generally earning good returns. The fishery is restricted to traditional fishermen only and they are required to purchase a licence on payment of a token licence fee. There is no license limitation to control fishing effort but fishermen are required to fish only with traps or pots (RDA, 1990).

The traps used are manufactured from plastic and hence are corrosion-resistant. They are easy to use and cause no direct injury to the lobsters (Appendix. 1). This is very important, since gravid female lobsters, which enter the traps, are required by the law to be released back into the water. The traps have openings on two sides, which facilitate the easy entry of lobsters. On average each fishing boat uses 25 - 40 traps (Mohan and Al-Amri, 1998) with dead sardines as bait. Local traders and fish processing companies operate in various parts of Al-Wusta and Dhofar regions. Each morning, fishermen land their lobster catches and receive cash payments from traders on the beach.

Table 2.1 shows the cost of lobster fishing to the fishermen and it is clear from the table that the cost of entry to fishing is just R.O. 1940, which the fishermen can recover quickly. The average operating cost is R.O. 7/trip. The average daily lobster catch is around 25 to 40kg, worth R.O 100 to 160 for each fisherman. A good season would provide not less than R.O 4000 per fisherman. Fishermen receive an average of about R.O 4.8/kg for lobster. These high prices have encouraged over-fishing even as stocks have declined. The weakened status of the fishery is reflected by the fact that the maximum catch is during the first two weeks of the fishing season. A similar situation in western Nova Scotia was reported by Miller (2003) that 50% of *Homarus americanus* catch is taken in first 20 days even though the season extends for 6 months.

Table 2.1 Cost of lobster fishing (Pers. com – fishermen, ministry staff)

Particulars	**Capital Cost (R.O)** After government subsidy	**Operating Cost/Trip (R.O)**
Boats (23 feet length)	1075	
Nets (6 nets/boat average)	240[1]	
Traps (10 – 15)	0[2]	
Engine (40 Hp)	370	
Miscellaneous	255	
Fuel		5
Food		2
Total	**1940**	**7**

1 – No subsidy for nets as they are banned; 2 – supplied by processors with part of government subsidy.

Although some fishery regulations exist, fishermen and traders alike generally ignore them since practical enforcement is difficult and the agencies under-resourced. Apart from the high returns, another factor encouraging over fishing is the ignorance of the fishermen with regard to fisheries management and how their activities might impact their livelihood in the long-term.

2.3 LOBSTER FISHERIES MANAGEMENT IN OMAN

The Oman government has taken some measures to protect stocks of spiny lobsters. Following collaborative studies with the Food and Agriculture Organization (FAO) in 1979 and 1994 and with the Omani - American Joint Commission in 1990 (Fisheries Development Project Report), the government decided to try and regulate the industry.

2.3.1 **Regulations**

The Ministry of Agriculture and Fisheries prescribed some measures for the protection of the lobster fishery. Article 14 of the Marine Fishing Law prohibits the catching of lobsters (and abalone) during their breeding and reproduction periods. Article 12 of the Executive Regulations stipulates that all fishermen should return juveniles of all fish species including lobsters (Al-Kharousi, 1999).

Specific measures for lobsters include a restricted fishing season (October 15 to December 15), a minimum landing size of 80mm carapace length, a ban on marketing berried (ovigerous) females and restriction of gear to government approved traps. Gravid and undersized lobsters must also be released back into the water with the intention of conserving stocks. However, it is not unusual for many under sized and gravid lobsters to appear on local markets (Appendix 1).

The minimum size regulation has been enforced based on the limited information available on the population structure and reproductive biology of *P. homarus* (Al-Abdulsalaam 1989; Johnson and Al-Abdulsalaam 1991; Liss *et al.*, 1994). This minimum size was based on the general understanding of size at first maturity. The minimum size requirement was determined in terms of carapace length (CL), which is used as the global standard. In Oman, the minimum legal CL is 80 mm. This is largely based on the understanding from other lobster fisheries where lobsters that have attained this size should have spawned at least once and hence supported recruitment to the fishery (Johnson and Al-Abdulsalaam, 1991).

2.4 REASONS FOR THE DECLINE OF THE SPINY LOBSTER FISHERY

2.4.1 **Change in fishing season**

During the 1980s, the lobster-fishing season in Oman extended over eight months from mid-August until mid-March. The only control measures during this period were a minimum legal size (80-mm CL) and a ban on the use of tangle nets. Following 27% decline in lobster landings from 2122 MT in 1986 to 1557 MT in 1987 (Fig. 2.1), the Ministry of Agriculture and Fisheries enforced a reduced fishing season of 5 months to reduce the fishing effort, particularly during the peak-spawning season.

The Ministry initially enforced a 5 month fishing season, starting from October until February (1988-90). The reason for selecting October was intended to reduce the fishing effort during the peak-spawning season. By October, the animals were still on the continental shelf allowing fishermen to catch them. But later in 1991, after a sharp decline of 42% in the landings from 1499 tons in 1990 to 874 MT in 1991, the Ministry decided to further reduce the fishing season to just two months. This time, the Ministry chose December and January when there was traditionally no fishing effort since fishermen considered this period to be the end of the lobster-fishing season.

The spawning season for lobsters starts during September and may last as late as February. The peak spawning takes place during September and October, during which time the lobsters migrate to shallow coastal waters (Johnson and Al-Abdulsalaam, 1991). This is also the peak season for fishermen to catch lobsters. By November the lobsters start dispersing and fishing is no longer commercially viable for the fishermen. This is evident from the landing data, which show a decline in landings during December in spite of the fact that fishing only opened two months earlier (RDA Fisheries Statistics Annual Report, 1988).

Restricting fishing during the peak season and forcing fishermen to fish during the barren period was perceived by the fishermen as a punishment and interference in their livelihood as the Ministry did not consult with the fishermen before imposing such

measures. Fishermen believed that this action was not in the interests of protecting resources. Consequently, in defiance the fishermen ignored the measures and continued to fish all year around for more than 10 years resulting in a reduction of resources, particularly in the Al-Jazir area. Chubb (2000) reported that a similar approach in Mexico with regard to minimum legal size led to fishermen ignoring the measures that lead to a subsequent collapse of the fishery.

2.4.2 **Lack of trained manpower**

The status of the lobster fishery in Oman is reflected by the fisheries sector as a whole. Instrumental to this situation has to some extent been the lack of experienced and properly trained fisheries staff. The few staff which had the foresight and necessary skills to provide advice on appropriate fishery management issues unfortunately remained as technical support staff with limited decision-making power.

The Directorate General of Fisheries within the Ministry of Agriculture and Fisheries is responsible for the management of fisheries in Oman. The Directorate has faced a continual problem in recruiting suitably skilled, trained and experienced staff. Knowledge of fisheries management and commercial exposure are pre-requisites for successful management of any fishery.

2.4.3 **Lack of vision**

The Directorate General of Fisheries took short-term crisis management measures responding to immediate problems rather than managing the lobster fishery as part of a long-term strategy (Al-Bahrani, 1995 and Al-Hafidh, 1999). With respect to Oman's abalone fishery, Al – Bahrani (1995) stated that the biological aspects of the resource should provide the foundations of sound management and sustainable development but are neither understood nor adequately investigated. The same scenario is also applicable to the lobster fishery and repeated failure to take the informed approach to lobster fishery management only served to exacerbate the decline in the fishery.

2.4.4 Violation of fishing rules

Fishermen in many areas continue to use nets and retain undersized lobsters and berried females (RDA Report, 1990; Liss et al., 1994). Al-Abdulsalaam (1989) reported that the traps used in Oman did not have escape vents and hence lobsters of all sizes were retained.

Improvements in the trap design were not undertaken and non-availability of traps in the local markets encouraged the fishermen to use tangle nets and more recently started using destructive nylon tangle nets (which are banned all over Oman for all fisheries) that harmed the lobsters prohibiting the return of berried and undersize lobsters. In contrast, Somalian fishermen in Puntland catch lobsters with tangle nets in October – November and use traps during February – April due to their belief that lobsters do not feed actively during spawning and hence do not enter the baited traps (Fielding and Mann, 1999). They further added that the lobster populations along the Yemen, Oman and Somali coasts probably constitute a single stock.

Violation of the minimum legal size regulation was encouraged by opportunistic traders. They provided outlets for lobsters of all sizes including berried females (Plate 1 & 4), which are transported to the United Arab Emirates (UAE). This activity is facilitated by poor border surveillance due to the lack of properly trained customs personnel in seafood trade regulations. While Omani fishery companies are bound by national regulations, companies in the UAE made significant profits since there was no jurisdiction to control such activities.

Catching of undersize lobsters is the largest single factor contributing to the continued decline of lobster stocks in California (Odemar et al. 1975). This problem in Oman probably contributed more than any other to the decline of the fishery as the UAE presented an open market for illegal landings irrespective of season. It is estimated that 65% of the fisheries trade in Dubai (UAE) is based on fish coming from Oman (Anon[9],

2005). This shows the extent of the impact of Dubai market on the state of Oman's lobster fishery.

During the mid-1980s, large numbers of non-local fishermen took part in lobster fishing during the peak season despite the law that clearly states that fishermen should not venture out of their region to engage in fishing activities mainly to avoid conflicts (Oman Observer, December 27, 1997). The Al-Jazir fishermen themselves initiated this practice as they were reluctant to spend long hours fishing but at the same time remained very possessive of their resources. During this period, fishermen from other regions outnumbered locals and prospered. As a result, clashes began to develop leading to a problem for the Government.

Subsequently, the Al-Jazir fishermen managed to drive out fishermen from other areas and for expediency resorted to employing expatriates (from India and Bangladesh) in their fishing boats over whom they could impose better control. Most of these expatriate fishermen originating from South Asia have a short commercial time horizon and cannot be expected to have regard for the sustainability of fishery resources. It should be also noted that as per Article 46 of the Executive Regulations of the Marine Fishing Law, expatriates should not be employed in the traditional fishing sector (Al-Kharousi, 1999).

2.4.5 **Failure in Monitoring**

Monitoring and enforcement of fisheries regulations was a problem as many of the fishing villages were quite remote requiring hours of travel along rough roads from the two major cities, Muscat and Salalah. Coupled with this, the Al-Jazir fishermen are not well-educated (Table 5.3) and can be quite aggressive. Fishery staff naturally had surveillance problems with these fishing communities whose lifestyle did not develop at the same pace as the rest of the country. This problem, combined with poor monitoring led to a further depletion of stocks with the situation being most severe in the final years of the 1990s (Fig. 2.1).

2.4.6 **Introduction of pots**

The introduction of new fishing gear, comprising a new lobster potting system also contributed to the failure. The performance of the pots, which were imported from USA, was mixed. They failed completely in the Al Jazir area as the openings of the pots were blocked by seaweed thus prohibiting the entrance of the lobsters. However, in some areas south of Al Jazir the pots were relatively successful, as the seabed in this area was rocky which precluded use of other capture techniques such as nets.

Further, the traps did not have sufficient escape gaps for the undersized animals. However, there was no attempt to make necessary improvements to pot design or import effective pots from other countries.

2.4.7 **Summary**

The main reasons for the current status of the lobster fishery were likely the continued use of nets in the absence of an effective lobster potting system coupled with fishing out of season and lack of effective monitoring. As stated in the Synthesis of Lobster Workshop Discussion (Anon[8], 2004), the prevailing attitude is to fish for today (to provide food or generate income) before any collapse occurs.

The situation deteriorated further with the introduction of foreign fishermen, who had no regard for the resource. They were aware that if caught they would lose this lucrative opportunity and be deported. However, they were also aware that their employers, who owned the fishing boats, would protect them. As a result of intensive fishing by ignoring the alarming status of the stock and the consequence of breaching the rules, many problems started to manifest themselves.

There were increased landings of small immature animals leaving fewer sexually mature animals to breed, while fishing out of season affects the spawning success (Al–Hafidh, 1999). Fielding and Mann (1999) stated that the average size of lobsters harvested at various localities of Oman in 1988/89 ranged from 62-82 mm in spite of the

government ruling of 80 mm CL. Studies by Mohan (1997) and by the researcher in this study also reveal that the average size of landed lobsters was below the legal size.

Inadequate and ineffective management of Oman's fisheries resources like lobsters will affect the economy of these isolated fishing communities. The coastal belt extending south of Masirah to Salalah is considered highly fertile in terms of its fishery resources and Al Jazir is a major lobster catching area with few alternative employment opportunities (Table 5.5, 5.6: Chapter 5). Fishing is a very important source of income with lobsters forming the main renewable resource.

One of the main problems in managing the fishery was its limited distribution with most of the catch (70% +) coming from the Al Jazir area. In the regional distribution of lobster landings for 1988, the Dhofar region accounted for 87.6% of total catch, primarily from the Al Jazir coast (Fisheries Statistics Annual Report, 1988 – RDA Contribution 89/2). Once known for catches of over 700 kg/boat/day, Al Jazir is now struggling to land even 4 – 5 kg/boat/day. Table 2.2 summarizes the regional lobster landing trends in recent years (Ministry of Agriculture and Fisheries, 2004). It should be noted that prior to the mid 1990s, Al Jazir was a part of Dhofar region and now it is part of Al-Wusta region.

Table 2.2 Regional trend in lobster landing

Year	Al-Wusta		Dhofar	
	Landing (MT)	Value (R.O. 1000)	Landing (MT)	Value (R.O. 1000)
1994	316	1201	263	999
1995	113	821	481	1681
1996	44	123	305	777
1997	36	99	222	718
1998	179	820	128	399
1999	16	37	152	457
2000	244	733	116	349
2001	72	248	291	1231
2002	220	836	178	719
2003	246	861	198	595
2004	94	375	111	437
Total	**1580**	**6154**	**2445**	**8362**

Source: Fisheries Statistical Yearbook, 2004.

Fielding and Mann (1999) stated that the entire stock of *P. homarus* in the north-western Indian Ocean comprising Oman, Yemen and Somalia has been heavily exploited and the catch rates have declined significantly. They further suggested that the Yemen and Oman lobster fisheries may have overcome heavy fishing pressure prior to 1990s due to the moderate exploitation of Somalian lobsters which continued to provide recruits to the region by way of the oceanic currents. Since the Somalian population is also now heavily fished, the supply of recruits is likely to have been reduced.

Thus, sound management decisions are required and their formulation will rely on a detailed knowledge of both the fishery and the biology of the animal. Furthermore, any fishery management plan will fail without the wholehearted support of its main stakeholders, the fishermen (Pomeroy, 1995).

Based on the present status of depleted stocks, the long-term perspective is ominous particularly in the absence of an effective and accepted long-term management strategy. In the following sections, the researcher attempts to provide certain management strategies that can be used by the statutory authorities to manage the fishery effectively.

2.5 IMPACT OF LOBSTER FISHERY DECLINE

Figures 2.1 and 2.2 emphasize the precarious position of the current status of Oman's lobster fishery. It is evident from the graphs that the total landings declined during the last decade. High demand and high prices in the international markets coupled with inadequate enforcement of fisheries regulations have brought about this situation.

In general, Omani fishermen do not understand the exact impact of failure to abide by fishery regulations. In relation to Oman's abalone fishery, Al-Hafidh (1999) states that although the fishermen know the rules and most of them realize the extent of decline, they still ignore the situation and continue to break the law. Fisheries managers increasingly recognize that a fishery cannot be managed effectively without the cooperation and participation of fishermen (Pomeroy and Berkes, 1997), but that degree of collaboration has not yet been achieved in the case of lobster fishermen.

Table 2.3 shows the quantity of lobsters confiscated by the government due to illegal size, berried or fishing out of season.

Table 2.3 Confiscated Lobsters during 2002 – 2005

Serial No	Year	Season	Quantity Kg		Total
			Hafit	Al wajajah	
1	2002	During season	936.0	3262.5	4198.5
2	2003	Out of season	7860.0	2602.5	10462.5
3	2003	During Season	1862.0	2169.5	4031.5
4	2004	Out of Season	669.5	0.0	669.5
5	2004	During Season	4358.0	1395.5	5753.5
6	2005	Out of Season	6254.0		6254.0
7	2005	During Season	6562.5		6562.5
Total			**15685.5**	**22246.5**	**37932.5**

Source: Ministry of Agriculture and Fisheries, Pers. com

SUMMARY

Although the government understands the problem and undertakes certain measures, its efforts are not yielding the desired results. Despite government warnings of the consequences of over fishing, the fishermen continue to secure enough income to survive from the lobster fishery and ignore government warnings. However, if the present trend continues, it is likely that the fishery will collapse in Omani waters affecting coastal communities dependent on this high value inshore fishery.

CHAPTER 3

ANALYSIS OF SIZE STRUCTURE OF SPINY LOBSTERS, *PANULIRUS HOMARUS* FROM COMMERCIAL CATCHES AT FOUR LANDING SITES IN OMAN

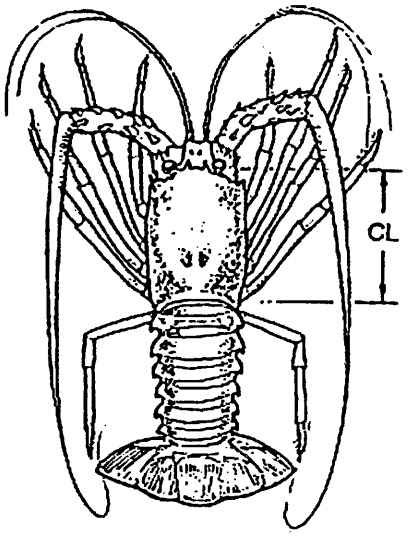
3.1 INTRODUCTION

One of the main objectives of fishery management is to allow exploitation of a fish stock for economic and social benefit while maintaining the reproductive capacity of the stock at a level that provides adequate recruitment to the fishery year after year (Chubb, 2000). The researcher's main contention is that the spiny lobster fishery in Oman is heavily exploited and has provided literature and statistical data that support this appraisal. In this chapter, the researcher offers further evidence based on size structure of the lobster *P. homarus* in the commercial catches from four different locations of southern Oman.

3.2 MATERIALS AND METHODS

The data used in size structure analysis in this study was collected by staff at Ministry of Agriculture and Fisheries, Sultanate of Oman from four different locations namely, Hadbeen, Mirbat, Sadah and Mugsyl during the fishing seasons of 2002 and 2003. The lengths were measured with dial-type Vernier callipers to the nearest 0.1 mm. The carapace length was measured along the mid-dorsal line from the transverse ridge between the supraorbital horns to the posterior extremity of the cephalothorax (King, 1995, Fig. 3.1).

The raw fisheries data was processed by the researcher for length frequency analysis by grouping the lobster size data according to their carapace length at 5 mm intervals. The number of animals in each size class was calculated as a percentage and used in the analysis. The researcher further grouped the data based on sex and the carapace length data were used and plotted as a frequency polygon using Microsoft Excel software.



(King, 1995)

Fig. 3.1 Standard carapace length (CL) measurement for lobster *P. homarus*

3.3 RESULTS

3.3.1 Size Structure Analysis

In all, 2846 lobsters were examined: 792 during 2002 and 2054 during 2003. The catch compositions are summarized for 2002 in Table 3.1 and for 2003 in Table 3.2. The percentage size frequencies of male and female lobster from the four centres are presented in Figs. 3.2 – 3.17. The median carapace lengths of lobsters caught at Hadbeen during 2002 were 74 mm for both males and females. In 2003, the levels recorded were 77 for both males and females. More than 60% of the catch belonged to sub legal size lobsters at this site for both years.

The median carapace lengths for samples at Mirbat were better with respect to sub legal size except for females in 2003. In Sadah, the median carapace lengths were close to sub legal size during both years. While in Mugsyl the median carapace length did not show much variation for males, there was appreciable variation in case of females. The median carapace size for female in 2002 was 77 mm compared with 80 mm in 2003 at this site.

Table 3.1 Catch composition of *Panulirus homarus* sampled in 2002

Particulars	Hadbeen		Mugsyl		Mirbat		Sadah	
	Male	Female	Male	Female	Male	Female	Male	Female
No. of lobsters	51	103	179	184	37	31	115	92
Min. Size (CL)	43	53	32	37	12	72	20	61
Max. Size (CL)	103	96	121	103	121	100	119	104
Mean Size (CL)	75	75	81	75	89	84	80	78
Median Size (CL)	74	72	83	77	88	81	77	76
SL lobsters (no.)	37	65	70	116	5	13	76	57
SL lobsters (%)	72	63	39	63	13	41	66	61

CL - Carapace length (mm); SL - Sub legal size (<80 mm)

Table 3.2 Catch composition of *Panulirus homarus* sampled in 2003

Particulars	Hadbeen		Mugsyl		Mirbat		Sadah	
	Male	Female	Male	Female	Male	Female	Male	Female
No. of lobsters	180	194	184	152	154	136	530	524
Min. Size (CL)	57	54	26	49	56	54	11	21
Max. Size (CL)	124	110	130	103	104	105	128	109
Mean Size (CL)	80	77	79	79	83	75	85	81
Median Size (CL)	77	77	82	80	83	74	83	80
SL lobsters (no.)	111	117	81	73	49	103	210	255
SL lobsters (%)	61	60	44	48	31	75	39	48

CL - Carapace length (mm); SL - Sub legal size (<80 mm)

The average overall percentage of sub legal lobsters for all sites during 2002 was 55% and during 2003 it was 49%. The minimum carapace length of 12 mm observed during 2002 for all sites was at Mirbat for male lobster. The minimum size recorded for female was 20 mm at Sadah. During 2003, the minimum sizes for males (11 mm) and females (21mm) were recorded in Sadah.

The maximum carapace length of 121 mm for males during the year 2002 was recorded in Mugsyl and for females the maximum size was 104 mm recorded in Sadah. During 2003 the maximum size for male was 130 mm sampled in Mugsyl and for the female the maximum size was 110 mm sampled in Hadbeen. The percentages of sub legal sized lobsters for combined sexes were higher at Hadbeen for both 2002 and 2003.

Figures 3.2 through 3.9 show the size structure variations among the four sites studied for 2002 and 2003. The results show a significant percentage of animals were below or close to the minimum legal size of 80 mm carapace length indicating that the fishery is showing signs of overexploitation. The data showed some variations for the mean carapace lengths of both males and females between all the sites studied. However, further analyses for these variations were not attempted in this study since the main focus was on whether the animals caught were below or above legal size. However this provides scope for a detailed analysis of variations in size structure in future.

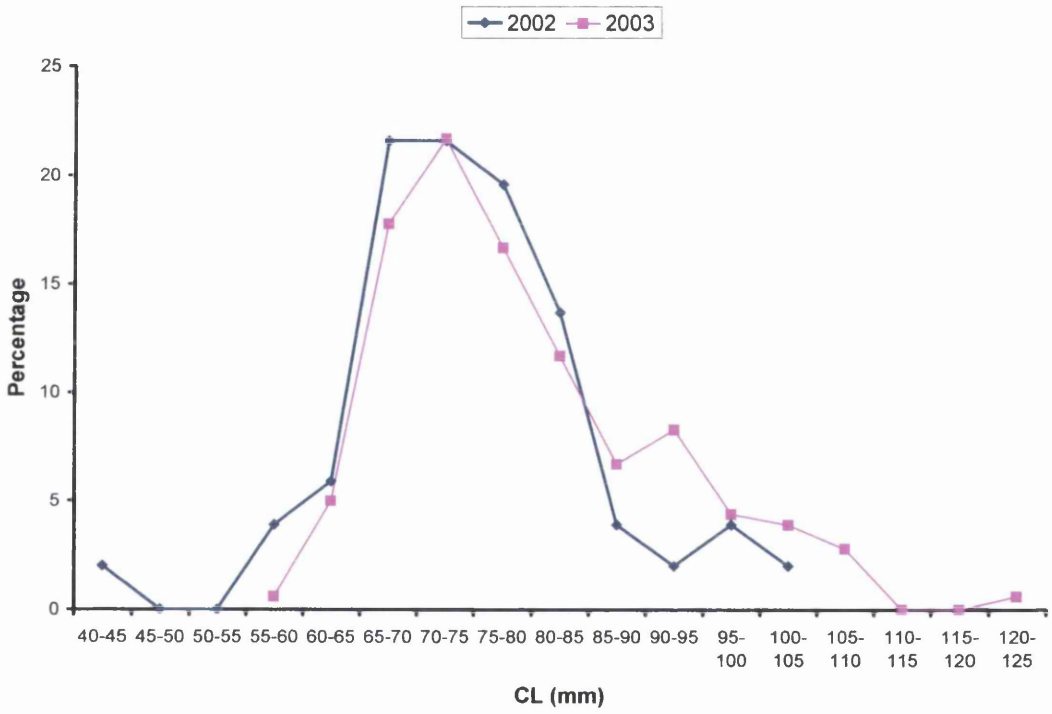


Fig. 3.2 Percentage size frequencies of male lobsters at Hadbeen in 2002 and 2003.

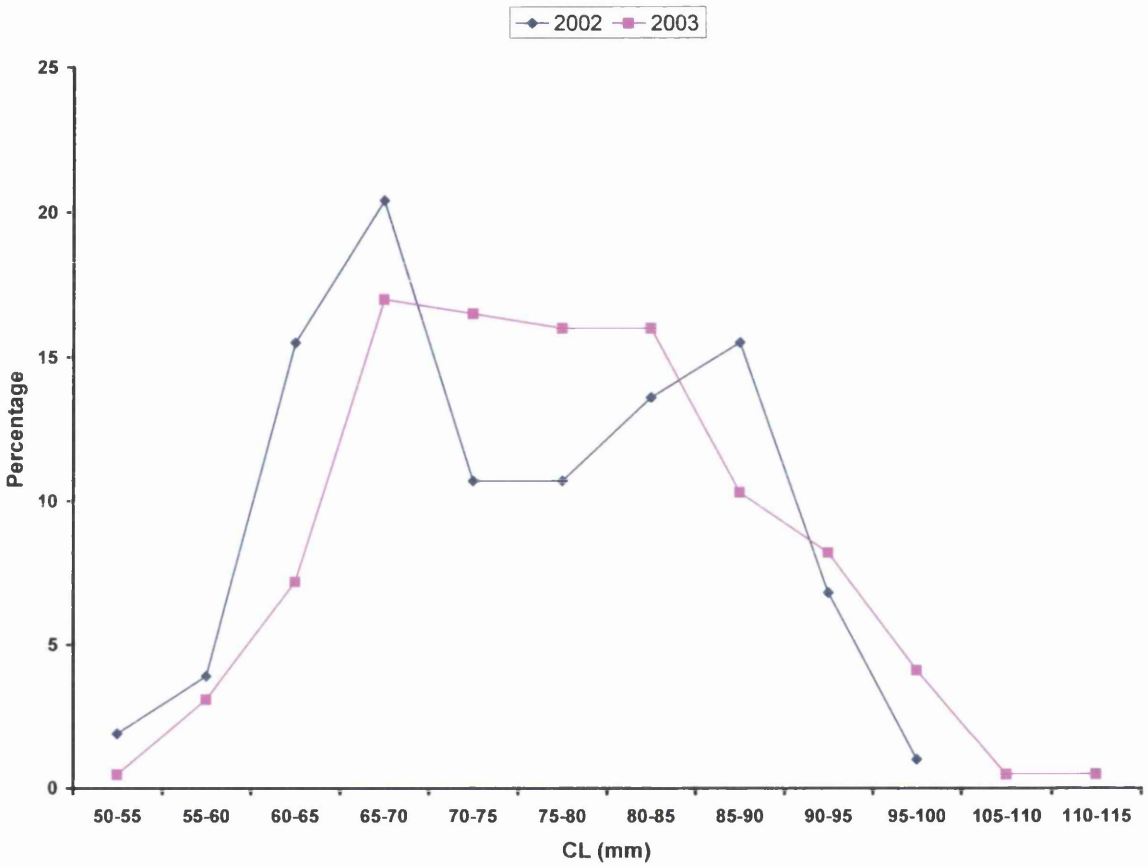


Fig. 3.3 Percentage size frequencies of female lobsters at Hadbeen in 2002 and 2003.

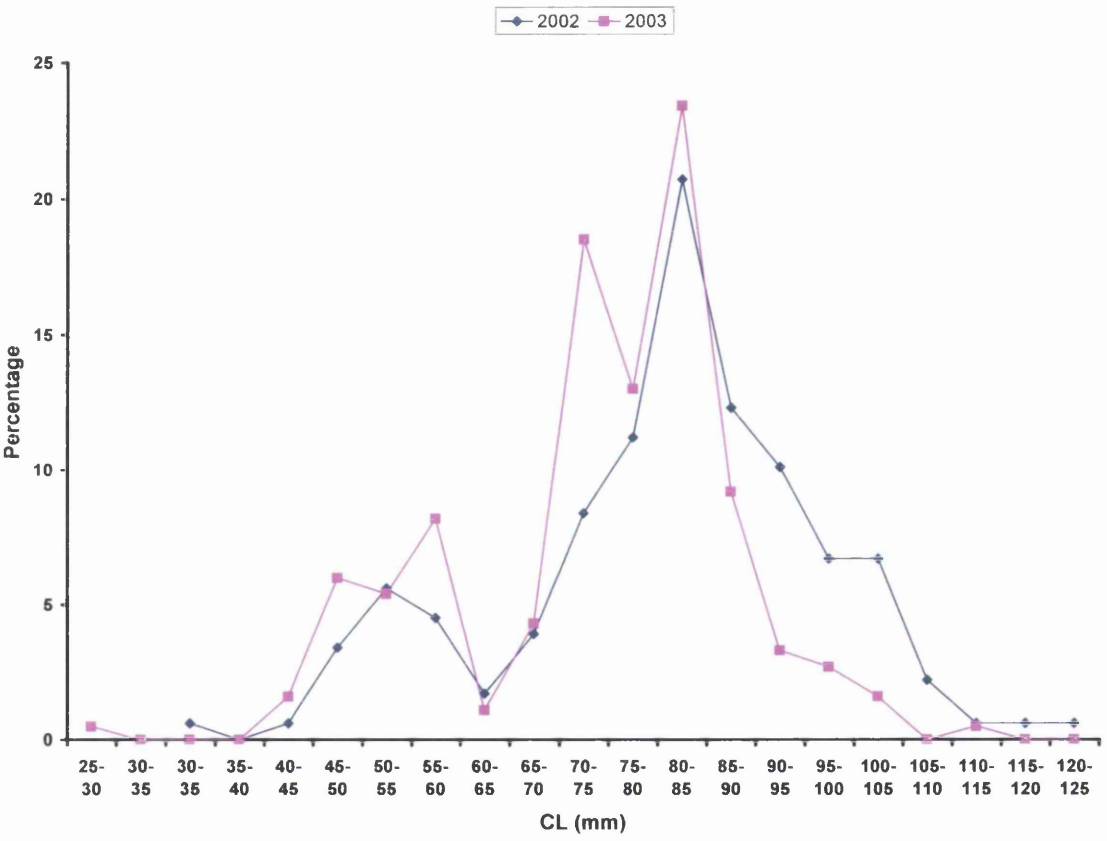


Fig. 3.4 Percentage size frequency of male lobsters at Mugsyl in 2002 and 2003

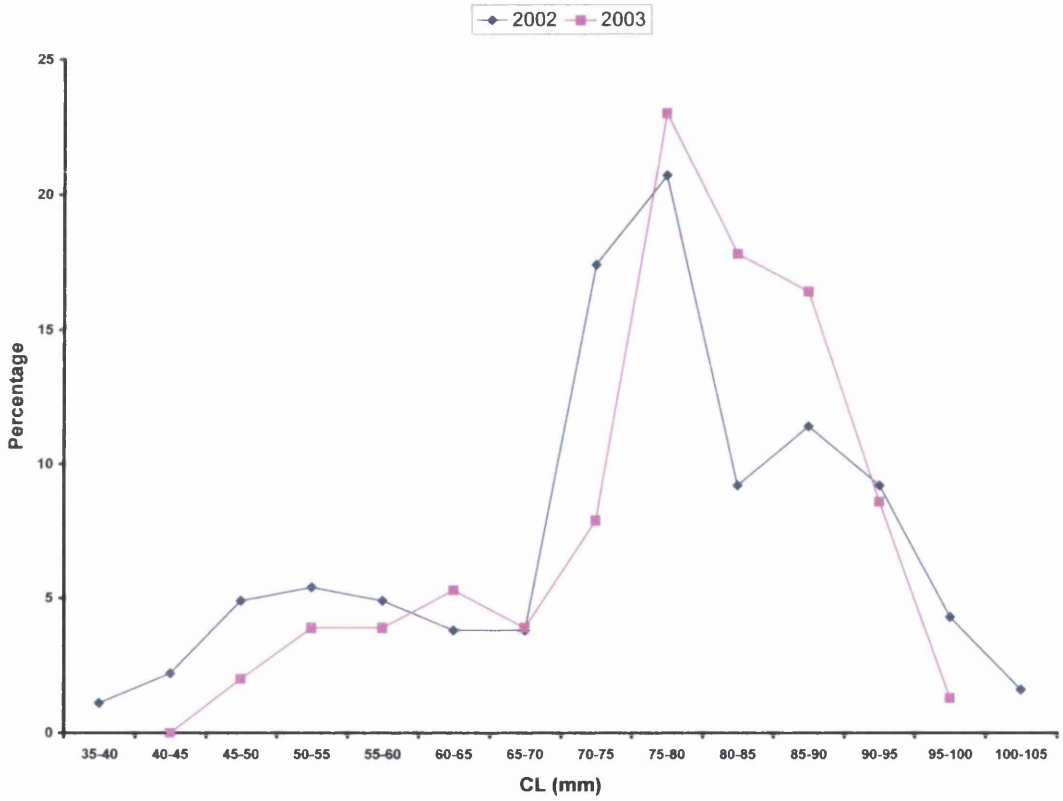


Fig. 3.5 Percentage size frequency of female lobsters at Mugsyl in 2002 and 2003

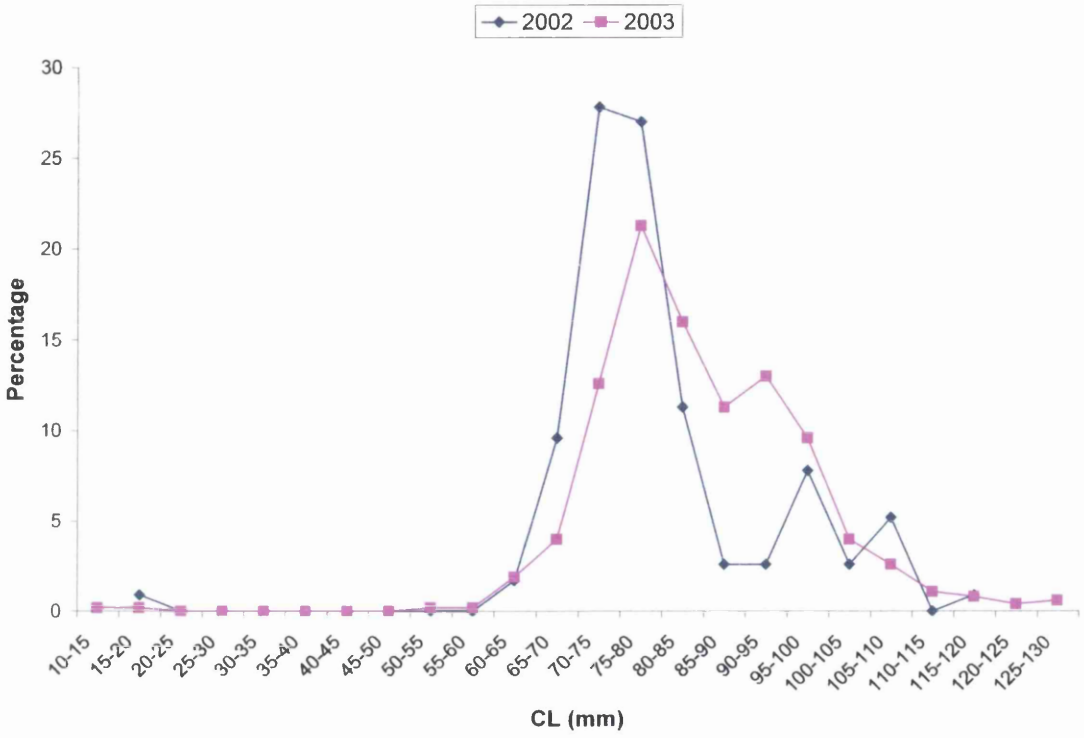


Fig. 3.6 Percentage size frequency of male lobsters at Sadah in 2002 and 2003

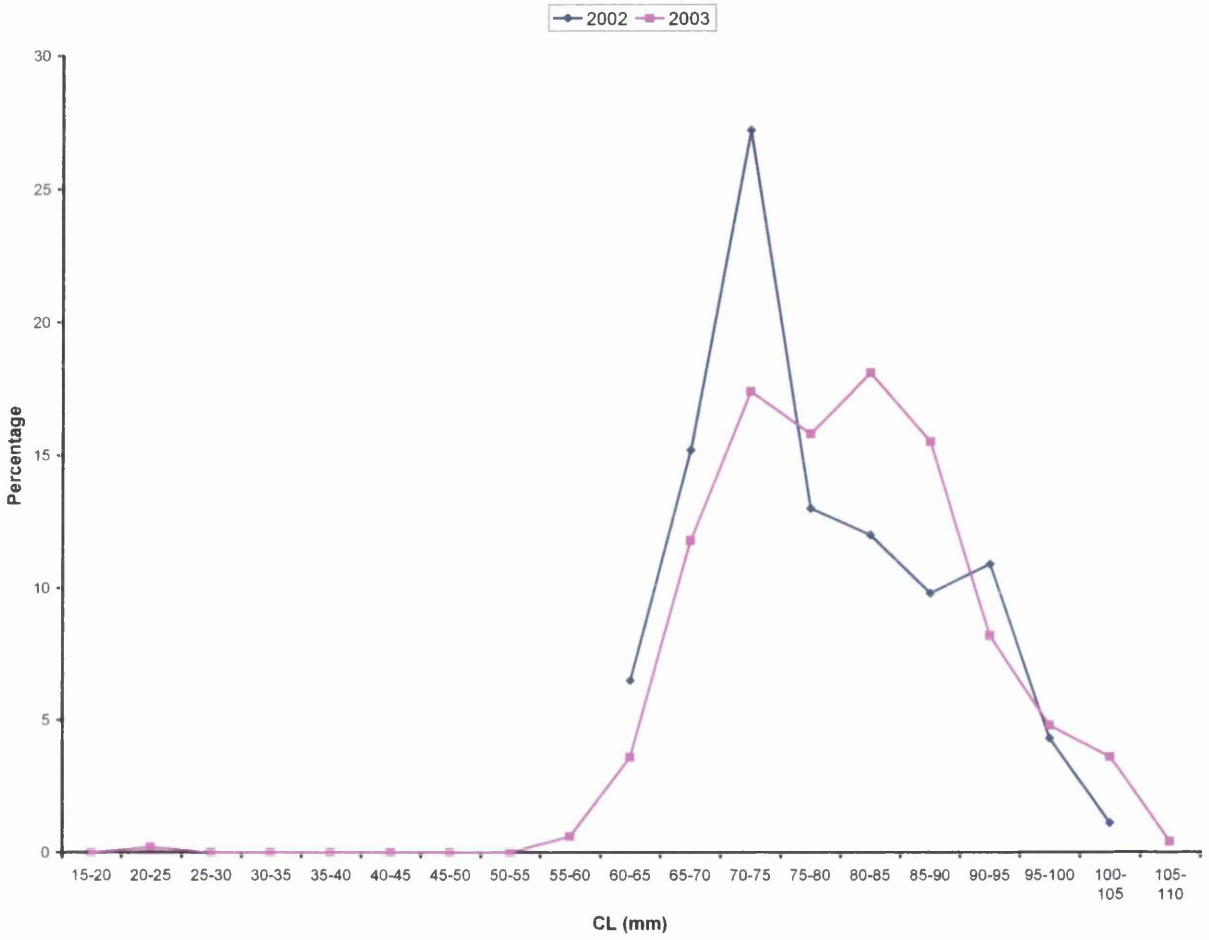


Fig. 3.7 Percentage size frequency of female lobsters at Sadah in 2002 and 2003

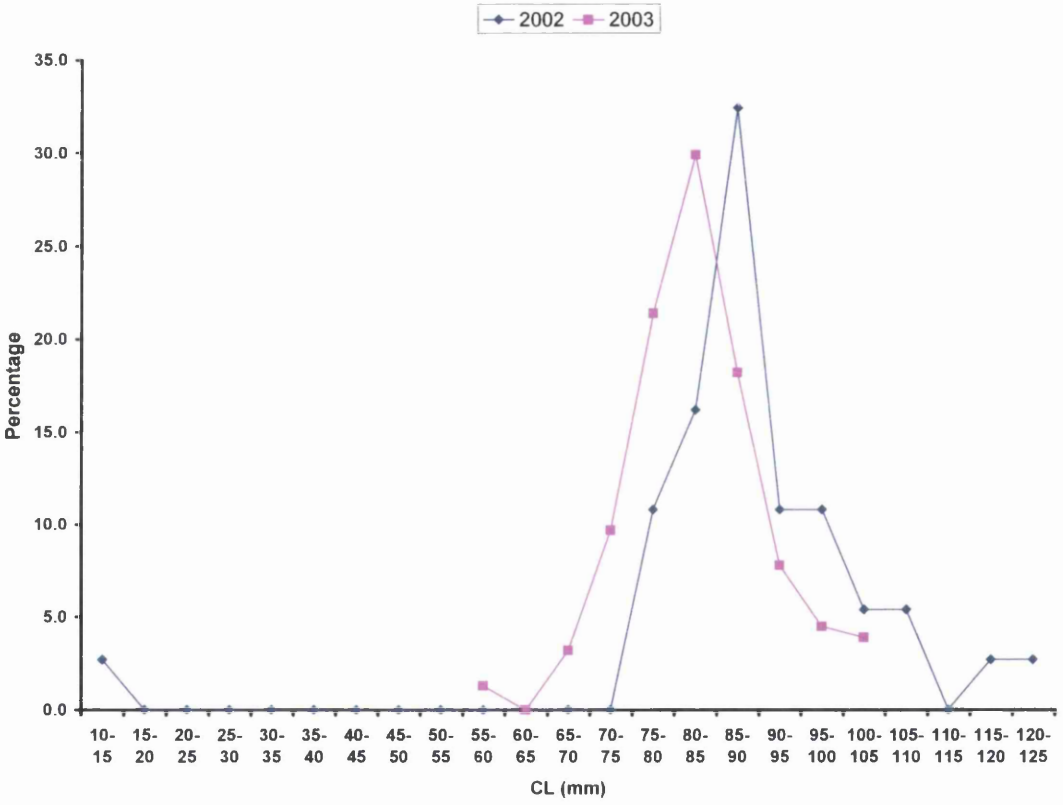


Fig. 3.8 Percentage size frequency of male lobsters at Mirbat in 2002 and 2003

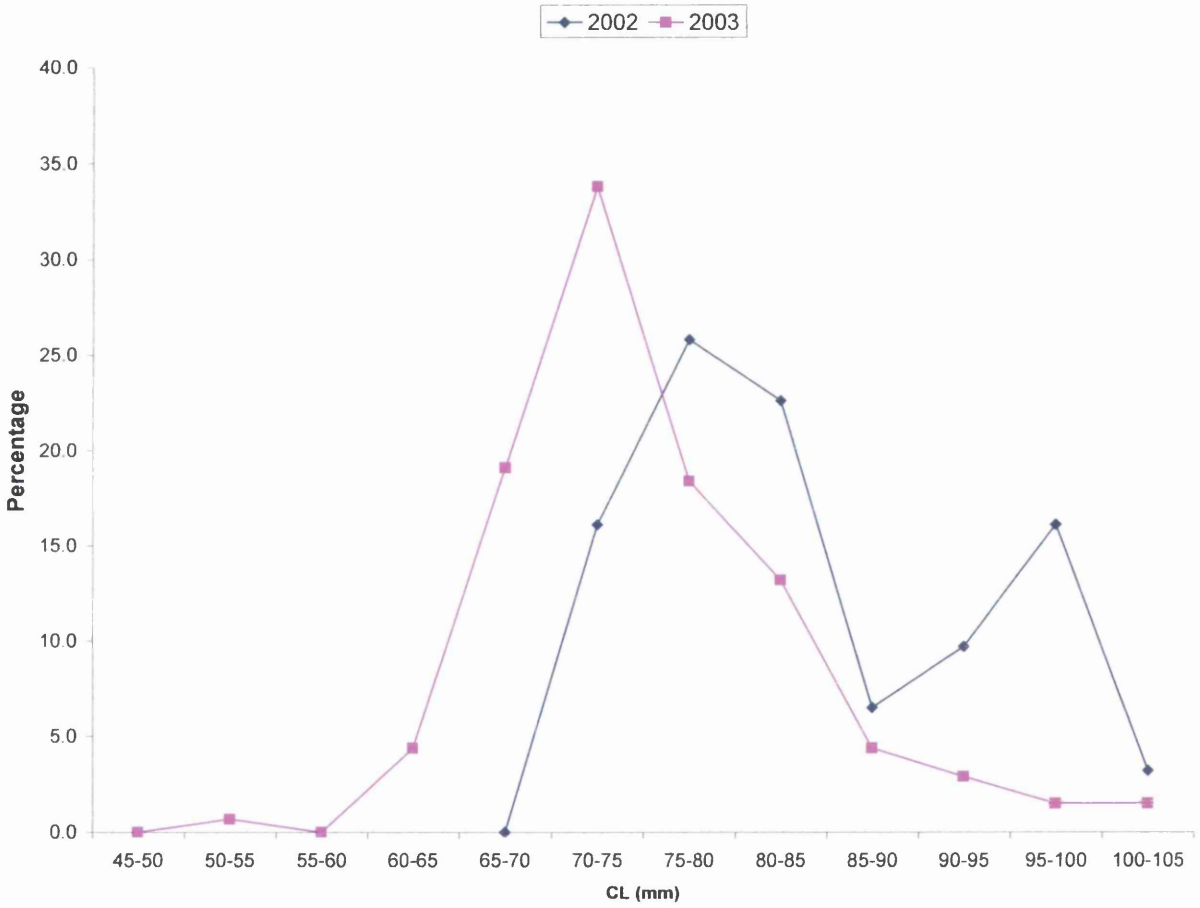


Fig. 3.9 Percentage size frequency of female lobsters at Mirbat in 2002 and 2003

3.4 DISCUSSION

In Oman, high variability among the lobsters with regard to size structure and reproduction has been reported (Al-Abdulsalaam, 1989; Johnson and Al-Abdulsalaam, 1991; Liss et al. 1994; Mohan, 1997). Such variations may be related to exploitation rate (Al-Abdulsalaam, 1989) apart from differences in environmental factors (Liss et al. 1994).

Estimates of the size at first maturity, size structure and external secondary sexual features of lobsters have often revealed the status of the fishery (Morgan, 1980). George and Morgan (1979) established the linear growth stage – intersect method to examine functional maturity in male spiny lobsters. This method indicates the size at which certain morphological differences begin to develop following the attainment of maturity. For example, 2^{nd} and 3^{rd} leg length in males and 5^{th} leg length in females and their relationship to the carapace length have been well established by various researchers (Morgan, pers. com). Evans et al (1995) however cautions that this approach requires the samples to be of varied size range to obtain a definite idea of size at onset of maturity (SAM).

The effect of fishing on SAM has been established for a number of fisheries. Under extreme fishing pressure, the fishery often exposed to density dependent changes in growth and SAM (Pollock, 1991). Apart from temperature, density, habitat and food availability, intensity of exploitation is also a major factor determining size composition and size at maturity (Mohan, 1997; Davis, 1977; Warner et al, 1977). Overexploitation appears to exhibit decreased SAM as a result of harvesting of rapid growing lobsters (Chubb, 2000). In the present study data on sexual maturity were not collected. Although size structure analysis provides evidence of overexploitation, future studies on sexual maturity will provide information regarding impact of fishing pressure on SAM.

SUMMARY

The results from the size structure study clearly indicate the scale of the problems relating to illegal harvesting of under-sized lobsters. Similar evidence was provided from four different sites and when combined showed that 55% and 49% of all lobsters landed at these sites, in 2002 and 2003 respectively, were below the minimum legal size.

These observations highlight a number of key management problems:

- Fishing regulations are not being enforced since undersized lobsters are being landed in large quantity.

- Ministry of Agriculture and Fisheries (MAF) continues to record undersized lobsters in their data collection but fails to address the underlying problems in harvesting by fishermen.

- Fishermen must be able to sell and benefit from the trade in undersized lobsters otherwise practices in harvesting would change.

- Capture of undersized lobsters would impact the egg production as large lobsters yield more eggs than just matured small lobsters.

- Continuation of such practice will impact the sustainability of fishery in the long term.

CHAPTER 4

SOCIO ECONOMIC STATUS OF LOBSTER FISHERMEN IN AL-WUSTA AND DHOFAR – SURVEY METHODS

4.1 INTRODUCTION

Effective fisheries management depends upon the collaboration of all stakeholders. These include the fishermen themselves, but also the fisheries protection services, research services, fish buyers and processors, suppliers of inputs, and also consumers. If an effective strategy for improved fisheries management is to be developed in Oman, it will be essential to canvass this wider range of stakeholders than has been possible in the current, more limited, study. For the purposes of this study, the view is taken that the fishermen themselves are the key stakeholder group because, based on personal experience of the investigator, it is here that we are likely to find the most entrenched resistance to improvements.

In the presence of active and appropriate institutional support, fishermen can make an important contribution to the management of fishery resources (Pomeroy and Berkes, 1997). Therefore, as a first step, a baseline study of the socio-economic status of lobster fishermen in the Al-Wusta and Dhofar regions was conducted. A number of questions concerning awareness and attitudes of traditional lobster fishermen to fisheries management principles and issues were also included in the survey to test how much they actually know about their problems and to supply signposts for the type of fisheries management measures that might be feasible.

This chapter opens with a description of the research methods adopted for survey design, collection and analysis of data. Chapters 5 and 6 present and analyse the research results.

The sites selected for the survey were based on the lobster landing patterns of the targeted study species *Panulirus homarus* and southern Oman has been selected for

the survey since most of the landings occur in this area. The detailed sampling plan is given in section 4.2.5.

4.2 RESEARCH METHODS

4.2.1 **Methods Selection**

Various methods can be used for socio-economic studies, including experimental, survey, observational, historical and qualitative methods (Frankfort-Nachmias and Nachmias 1992). A common approach in social science is the survey method. This consists of sample design, questionnaire, testing the validity and reliability of the method and questionnaire, data collection, and analysis of descriptive statistics and inferences. In this case it has been selected as the main instrument for the study because it enabled the researcher to obtain an assessment of attitudes alongside certain factual details about the lives of respondents.

The purpose of this study was to analyze the individual and collective behaviour alongside the socioeconomic status of lobster fishermen in two regions of Oman. As the Omani lobster fisheries are concentrated in the Dhofar and Al-Wusta regions of Southern Oman, these were selected as the target area of this study.

4.2.2 **The Survey Design**

The main elements of the design of a survey are a well-defined sample and a questionnaire or other data collection procedures, which satisfy the study objectives (Kish, 1965, Frankfort-Nachmias and Nachmias, 1992). However, sample surveys are not without their problems. The following comments are based on Ellis (2000).

1. the timing of one-visit surveys, eg the period when the sea is rough, or during the period of a religious celebration, can make significant differences to the variables (such as income, catch rates or prices) under investigation;

2. many surveys collect data from the head of the commercial unit only, so the incomes received from the same activity by the other members of the unit can easily be underestimated or neglected altogether;
3. some surveys have been known to report just the net income from the *main* line of activity, eg fishing or farming, thus (possibly mistakenly) supporting the idea that fishermen or farmers have only one line of economic activity;
4. many surveys do not ask whether there are absent contributors to the joint income of the fishing vessel;
5. self-employment creates special difficulties because, to arrive at a net figure, data are required on both revenue and costs, otherwise the decisive net figure for income – the income upon which commercial decisions are taken – can be overestimated.

4.2.3 **Sampling Frame**

The sampling frame is the list of units from which a sample is drawn. The word "population", in the survey context, refers to the entire collection of people or things of a particular type taken for study. In this study the total population might be taken to refer to the total number of vessel-owning or operating fishermen in Southern Oman. However, for reasons explained below, this study concentrates on fishermen who are known to undertake directed fishing for lobsters. Therefore the population was whittled down to the individual fishermen/boat owners and operators in the lobster fishery, who, in the judgement of the researcher, are most likely to be undertaking directed fishing for lobster in the two regions under review.

As a result of prior personal experience, the investigator has found that there are number of boats operating in the region without registration. Therefore there is no strictly accurate record of the actual number of boats operating in the region. The basic list of vessels and their owners has been obtained from the Sultanate's Government[13]. Personal knowledge of the fishery has enabled the researcher to add some fishermen who are unregistered lobster fishermen to the sampling frame and to remove fishermen who are

[13] Ministry of Agriculture and Fisheries, 2003

known to be undertaking directed fishing for other species. Thus the population from which the sample has been drawn consists of people who are known to be operating in the lobster fisheries.

4.2.4 **Sample Design**

Sampling is a way of generalising about the population from the detailed examination of a component of that population. Important considerations in the sample design are the degree of representation and, if it is intended to conduct statistical tests, some element of randomness in the selection procedure depending on the population characteristics and other factors (Healy, 1996).

However, in social survey, randomness may not be always possible or desirable.

Sampling types can be divided in to two types namely 'probability' and 'non-probability' sampling. *Simple random sampling* is employed in the quantitative research methods or statistics classes related to study on human subjects[14]. In this case, there is an accessible list of members of the population available for selection. They have no distinguishing features, and each has an equal chance of inclusion in the sample (Som, 1996). But when the population size is very big, this approach is very difficult.

In natural resources and social science surveys, the geographical area may be much wider, population details either do not exist or are in a disorganized form and the population size may be very big. Therefore simple random sampling is seldom applied in practice. As noted by Som (1996), "to save time and money in such a situation, researchers often use a technique called *systematic sampling*, where only the first case is randomly selected, there after every k^{th} case is selected".

In the present study, the systematic sample method, as outlined above, was initially conducted as a pilot survey. A first number was selected randomly and thereafter every

50th boat registered with the Ministry of Agriculture and Fisheries was selected as a unit in the sample to be studied. However, in reality it was found that some of the sample data were obsolete as some boats had moved to other regions. Consequently, surveying in this manner was not appropriate, as the samples would not represent the true characteristics of the population. Thus the research rapidly came face to face with one of the difficulties of conducting social research, namely evidently weak population data which could only be corrected at great time and expense, work which could not be done within the scope of this research project.

Another type of sampling method widely used is the stratified sample. *"Stratified sampling is a plan by which the universe is divided into subgroups (strata or classes), and samples are taken from each class as if it were a separate universe."* (Deming, 1950). Environmental and natural resources often have such large variabilities that stratification is often helpful; it enables the researcher to ensure that the various natural groupings within the population are adequately represented. Without stratification there is always the risk that the sample will, by chance, be unrepresentative of the population as a whole. Cochran (1977) lists 4 reasons to stratify: analytical convenience, administrative convenience, operational convenience and potential increase in precision of the research.

This technique is often desirable, especially in social science and natural resources surveys, because it provides some assurance that the sample will be representative of the focus of the study. To apply this technique, the population is grouped into sub-lists according to some relevant criterion (Healy, 1996). The number of samples from each sub list is selected according to that characteristic, thus the sample is representative of the population.

Sampling in Asian countries, such as the coastal regions of Oman, poses many challenges due to various parameters like unstable populations such that sampling frames

[14] Some basic ideas of sampling, University of Reading, http://www.reading.ac.uk/ssc/ accessed on 23/10/2005

quickly become outdated, populations for which no sampling frame exists or accurate (like unregistered boats), poor literacy, and accessibility.

The author of the present study started his career with the Development Council as Head of the Department for Fisheries Statistics[15]. During this period he travelled extensively along the Oman coast, visiting every fishing village in the country, obtaining statistical information and interacting with the fishermen. Later he joined the Oman Fisheries Company and had an even greater opportunity to interact closely with the fishing communities, even to the extent that he knew many fishing village heads and individual fishermen personally. This experience and industrial knowledge gained over more than 20 years assisted the researcher in applying stratification and the sample selection methods employed in the present study.

4.2.5 **Sampling Plan**

In this study the targeted area, Southern Oman, is stratified into two subgroups, namely the Dhofar Region and the Al-Wusta Region. These regions are further divided into smaller areas called "fishing activity centres". The main criterion applied to achieve this stratification is the geographical demarcation. Further stratifications are based on the concentration of the lobster fishing activities according to the personal knowledge of the researcher. The Dhofar region is the wider (in the sense of extending over a longer coastline) of the two with more fishermen fishing lobsters in some selected areas, as well as demersal species, whereas the Al-Jazir area in the Al-Wusta Region is the major lobster landing centre for the entire Sultanate of Oman.

The fishing areas and villages in the Al Jazir area (Al-Wusta) are not permanent fishing settlements. They are basically seasonal fishing activity centres. During the fishing season, the fishermen of these villages move freely within the Al Jazir area for fishing and any fishermen from this area may camp in any other village in the Al Jazir area for as many days as they wish, depending on the viability of their fishing efforts in that particular village. The duration of the stay in any particular village varies from hours to

[15] Ministry of Economy, Sultanate of Oman.

days depending upon the catch. Therefore, there is no specific registered list of fishermen operating in these centres. Also these are all very remote locations, with tough living conditions.

In this situation, stratification sampling cannot be practiced on the basis of registered fishermen alone as it is neither complete nor up to date and will not reflect the reality of the fishing situation. Therefore a decision was taken to stratify the population on the basis of size and characteristics of the Fishing Activity Centres (FAC).

FACs were not created by any government administrative regulation. They evolved over the years based on the pattern of landings and the self-imposed rules and regulations of the ethnic groups and tribes settled around the areas. Therefore FACs are more likely to reflect the true picture of fishing activities in the region as well as the fishermen's dependence on the fisheries.

Based on size and characteristics of the FAC, with due weighting to lobster landing centres, the population was stratified into ***Magsail, Rasyut, Marbat*** and ***Dalkut*** in the Dhofar Region and ***Sharbatat, Lakbhi, Duqum, Haitam*** and ***Mahoot*** in the Al Wusta region (Fig. 4.1). Magsail, Rasyut, Marbat and Dalkut are the major lobster landing centres within the Dhofar region and were considered as FACs for the present study. Similarly Sharbatat, Lakbhi, Duqum, Haitam and Mahoot were considered as FACs within the Wusta region. A sample size close to 30 was fixed for each FAC (Table 4.1). It should be noted that although Sharbatat has recently been moved to Dhofar region for administrative reasons, for all practical purposes it is still part of Al Wusta region and was treated accordingly in this study.

There is no clear-cut method to answer the question, "How big a sample do I need?" The sample size often depends on the type of study method, the desired level of confidence, amount of accuracy and the characteristics of the population studied. Increasing the sample size does not increase proportionately the accuracy of the result. A sample size of 201 was fixed for the purpose of this study with 101 samples from Dhofar Region and 100 samples from Al-Wusta/Al-Jazir region.

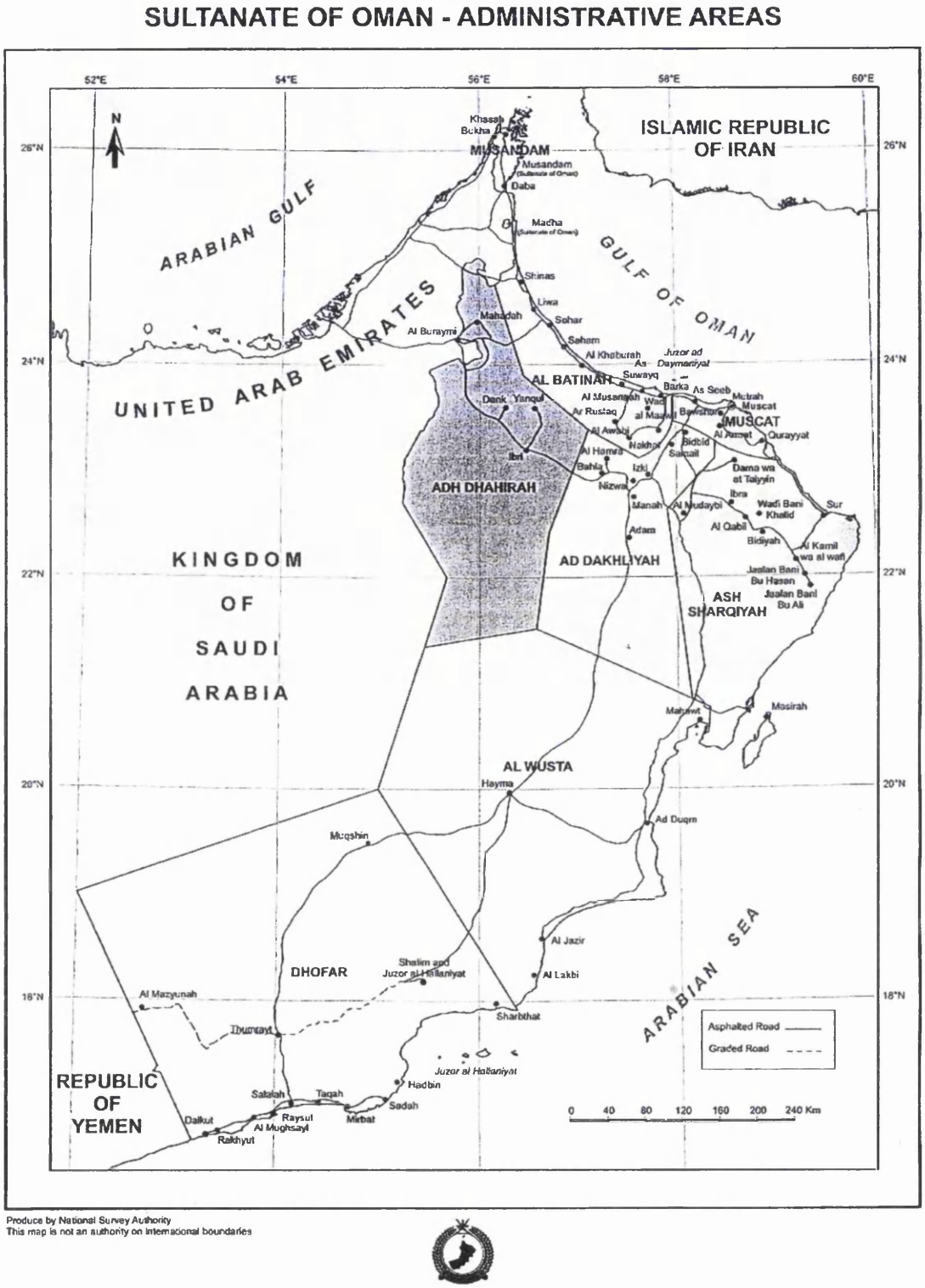


Fig. 4.1 Map showing the survey areas in Southern Oman

(Source: Ministry of Defence, Oman)

The fishermen were selected for interview on the basis of a disproportionate stratified sampling method[16]. However, some of the fishermen in this region were not co-operative and unwilling to respond to the survey fearing that punitive measures may follow their involvement in the survey. Hence, only those fishermen who offered to participate in the survey were taken into consideration.

The Al Jazir area in the Wusta region is the main lobster landing centre in Oman. Therefore, more importance was given to this area as this project revolves around the lobster activities of this area. Mahoot is recognized as the shrimp-landing centre while Duqum is the main fish-landing centre but they were also covered in this survey as they are administratively part of the Al Wusta Region.

[16] *Disproportionate stratified sampling* is the term used to describe the situation when there are variable sampling fractions applied to each stratum of the population (Frankfort-Nachmias and Nachmias (1992) page 180).

Table 4.1

Sampling Plan

Strata	Village		FAC *	Sampled	Fishermen
			Dhofar		
I	Salalah Rasyut Haffa Dahreez		**Rasyut**	26	1530
II	Magsail Auqad		**Magsail**	33	
III	Dhalkut	-	**Dalkut**	12	289
IV	Marbat Taqa Sadah Hasik		**Marbat**	30	1219
	Dhofar - Total	**101**		**101**	**3038**
			Al-Wusta		
I	Lakbi Sograh Madar Gasid Fadhi Kahal Khadrah	**Al Jazir Region**	**Al Lakbi**	28	750
	Haitam		**Haitam**	25	
II	Sharbatat Al shuwimya		**Sharbat at**	26	500
III	Duqum	-	**Duqum**	10	600
IV	Mahoot	-	**Mahoot**	11	700
	Al-Wusta - Total	**100**		**100**	**2550**

* FAC - Fishing Activity Center

4.2.6 **Questionnaire Design**

As the purpose of this study is to assess the collective and individual attitudes and decisions of fishermen in Al-Wusta and Dhofar regions, individual fishermen's responses were investigated. Data for this were collected by means of a standardized procedure (in this case, the questionnaire) so that every individual was asked the same set of questions in the same way.

In general there are many methods used for obtaining survey data. These include participant observation, interviewing, conference, Delphi technique, nominal group technique and focus groups.

Focus groups method involves an in depth discussion among a group of 4 – 12 people. Even though this method generates in depth information, it is difficult to analyse. The conference technique involves discussion among a group of experts in a common location and the most popular response will be chosen based on logic but may be influenced acording to individual personalities. The nominal group technique requires that the group members writing down their response without any discussion and the responses will be discussed and critical items are selected according to the order of priority. Since the main unit of study is fishermen living in remote areas, the above methods cannot be used.

The Delphi technique is where the expert's opinions are derived without bringing them together at one location and often involves many rounds of sending the questionnaire to the experts, which again is not feasible in this study. The qualitative research method is mostly used in the fields of socio-psychology, cultural or psycho-anthropological studies.

After considering the various options it was decided to use the structured interview. It has already been used successfully in another region of Oman (Al Oufi 1999) and the researcher was therefore able to build on the experience of others who had employed the same technique. The progress of the research also confirmed some of its negative features

– expense, rigidity, formality, repetitiveness (www.okstate.edu[18]). However the structured interview is relatively efficient in quantifying the data for subsequent statistical analysis. Hence, a structured interview method was administered through a predefined questionnaire to collect data. In addition, direct observations were also used to infer characteristics such as self-control, cooperativeness, truthfulness and honesty. This enabled the researcher to observe directly other relevant traits of fishermen and the fishing community in general.

Constructing an effective questionnaire is a complex process, particularly for a fishing region, which has not been studied previously. Consequently, a review of an earlier fishery survey (Al-Oufi, 1999) performed in another region of Oman was referred to for guidance, but modified to suit the specific fishery under consideration in this study.

A significant change from the Al-Oufi study was the introduction of some questions designed to focus on some broader fisheries policy issues. The problem foreseen by the researcher is that some lobster fishermen are known to be suspicious of outsiders. Some are culturally separate from the Omani majority and perhaps they fear interference with their way of life.

Goodman (1996) presents an account of how data should be collected and analyzed including appropriate survey techniques. Once the mode of survey is determined, the next step is a detailed survey plan including the preparation of questionnaire (Appendix III).

Questions are broadly classified into two types:

a) The open questions may elicit free response from the respondent and allow a greater depth of response. However, using this type of question will create problems of data interpretation.

[17] Questionnaire and interview as data gathering tools at http://www.okstate.edu/ag/agedcm4h/academic/aged5980a/5980/newpage15.htm

[18] Questionnaire and interview as data gathering tools at http://www.okstate.edu/ag/agedcm4h/academic/aged5980a/5980/newpage15.htm

b) The closed questions, in which the questions call for a "yes" or "no" answer, short response or item checking and is fairly easy to interpret, tabulate and summarize. However, the respondent would not be able to express his/her views on the question and possible further lines of enquiry might be inadvertently curtailed.

Questions in the questionnaire employed here were mostly of the closed type but wherever the researcher felt the need to elicit more information from the fishermen, he followed up the closed questions with a brief discussion. These open questions were *impromptu* and stimulated by the response of the fisherman in question. Thus the path for following up lines of enquiry was left open.

The questionnaire was divided into nine sections:

1. General section - where the name of fishermen, town and other details of general nature were identified.
2. Fishing assets
3. Fishing activities and fish marketing
4. Current status of fish resources
5. Collective activities in fishing communities
6. Factors that may influence collective activities
7. Attitude towards investment in fishing
8. Establishment of fishermen co-operatives.
9. Assessment of fishermen's attitudes towards cooperation

The three categories for investigation were (a) classification or descriptive questions: such as age, ethnicity; (b) behavioural or factual questions; and (c) attitude questions. Some questions were designed so that they supplied an internal system of cross checking, or triangulation, to improve the likelihood of accuracy and consistency of response.

Following Al-Oufi's practice, the researcher decided to use a summated rating scale to measure the strength of attitudes. The most common form of summable scale in studies such as this is the Likert Scale (Likert, 1932). The Likert scale is the most widely used method because it is relatively easy to construct and, according to the literature, tends to

be more reliable than other scales with the same number of items (Tittle and Hill, 1967) even though they are subject to fakability and self-deception (Hopkins and Stanely, 1981).

The fishermen's attitude toward resource status, overfishing and the consequences of over fishing are measured using Likert's summated scales (Sprinthal 1987). For Likert scale exercises summated scales may use up to 7 points to measure the intensity of the attitude expression (e.g. agree very strongly (7), agree strongly (6), agree (5), disagree (4), disagree strongly (3), disagree very strongly (2) and, no response (1)), whereas considering the literacy level of the fishermen in this study, the responses were restricted to 3 points viz. agree (3), indifferent (2) and disagree (1).

The questionnaire for the present study was prepared with the above elements in mind. In total, 201 fishermen were interviewed for the survey and each interview lasted around 45 minutes.

4.2.7 **Data Collection**

The data were collected directly from fishermen through personal interview. Personal experience has shown that, in contrast to the Al Batinah region, fishermen from Al Jazir are mostly illiterate, aggressive and can be very hostile in nature. On occasions, they have been known to manhandle surveillance staff and they always look suspiciously at people coming from other regions to collect information. No other fishing community in Oman shares quite these characteristics.

Official surveys conducted in these remote areas, especially among the fishing communities, are usually interpreted locally as ultimately leading to either the implementation of more rules and regulations that would be opposed or to provide subsidies and develop infrastructure. Consequently respondents may manipulate their responses according to their best interpretation of either of these two possible outcomes.

Since the researcher is familiar with the people, culture and general structure of the area where the study was to be conducted the researcher did not carry any formal introductory letters from governing authorities. A perceived official connection could have worked against the purpose of the study as the fishermen may have interpreted it as government related research and cautious of their answers. The researcher also did not formally record the interview in any medium other than the questionnaire as this would have offended them and would not have give them the confidence to exchange their views openly. Therefore, the researcher visited the area and after having informal discussions with the village heads approached the selected fishermen for the interview and data collection.

Some times the interview was conducted at the landing site or alternatively it was held at the respondent's residence during their rest time. The interview normally started with the exchange of pleasantries as the tradition of Omani culture. This involved a general discussion about the well being of the fishermen's family for at least 5 to 10 minutes. It would have been totally unacceptable to immediately commence asking questions on arrival, which would have been considered a hostile approach.

After the initial pleasantries, the researcher started with the general questions from the questionnaire and followed up with the direct questions. Sometimes the researcher mixed and skipped between general and direct questions in such a way that the direct questions were mostly asked when the respondent gained full confidence with the interview process. The researcher also preferred to observe the activities of these fishermen directly during the period of the survey both through passive participation and through informal chatting with these fishermen.

4.2.8 **Testing the Validity and Reliability**

As stated by Warwick and Linninger (1975), the two basic goals in the questionnaire design are to obtain the information relevant to the purpose of the survey and to collect this information with maximum reliability and validity.

In many ways social science research differs from research in the fields of physics and chemistry. In the latter subjects and other scientific experiments the elements, actions and results can be measured in terms of standard units of measurements like metres, litres and grams, whereas in social science research the researcher is trying to measure various non -quantifiable elements such as attitudes, behaviours, emotions and personalities. Therefore social scientists have developed their own method of measuring such concepts[19].

In the context of this research study, validity addresses whether the questions set were relevant to the study objective. Whereas the reliability is concerned with the accuracy of the actual measuring instrument (Yu, 2005). The validity of the questions was further classified into face validity, content validity.

4.2.8.1 Face Validity

This refers to the validity at face values like appearance, simplicity, openness of the questions, and degree of difficulty. Face validity is usually established through peers. In this study, advice was sought for the layout of the questionnaire from the research supervisor in Oman.

4.2.8.2 Content Validity

Content validity is similar to face validity except that instead of review from one person, it should be established by a group of experts in the study field. Therefore the researcher used a content validity questionnaire (Appendix – IV A) for measuring concepts like the status of current lobster resources, effects of overfishing, willingness to cooperate, on a total of 12 experts (3 from the Ministry of Fisheries, 2 from fishing companies and 7 who were university professors or lecturers). The experts were asked to make judgments about the degree (i.e. responses in the scale of *1 - Not at all Appropriate, 2 – Fairly Appropriate, 3 – Moderate, 4 – Appropriate and 5 – Extremely Appropriate*) to which the test items matched the test objectives or specifications.

[19] http://www.socialresearchmethods.net/tutorial/Rymarchk/rymar2.html

The experts' feedback results were tabulated and a mean value for each question and group was analyzed and given in the Appendix IV B.

The mean for the scale "Perception of resources status" was 4.07 and four out of 5 questions in the group scored above the average mean except for the item "the percentage of trash fish / young lobster in your catch increased". However, considering the importance of the question it was retained.

The mean for the scale "Overfishing" was 3.98 and 5 out of nine questions were below the group mean. Considering the importance of the questions 3 and 4 they were retained and the questions 2, 8 and 9 were removed from this scale. Since the questions 6 and 7 were almost similar, the researcher changed the question 7 with "lobster resources decline if fishers use destructive gear". It should be noted that the researcher is permitted to retain any part of questionnaire even if validity value does not meet the mean value (Al-Oufi, 2001) if he feels that the questions which add to understanding of the issues.

The scale "The consequence of overfishing" has a group mean of 3.9. The scale had 8 items and the items 1 and 8 that received a low mean were removed from this scale. The scale "benefits from collective conservation activities" had 4 items. Even though the item 1 scored 3.25 and item 3 scored a mean of 3.83, both below the scale mean of 3.85, the researcher felt that these items should be retained. The scale "externalities in coastal fisheries" had 7 items. After the expert analysis a mean of 3.33 was obtained for the scale and items 3, 4 and 6 were below the scale mean. Considering the importance of item 4, it was retained while items 3 and 6 were removed from the scale.

The scale for determining the fishermen's "willingness to cooperate" had 14 items. The mean for the scale was 4.27. Therefore items from 11 – 14 which had a mean value below the scale mean were removed. The researcher also modified the question M99 to "Own artificial reefs". Finally, the questionnaire was modified according to the feedback received from the external experts. Based on expert advice two questions were added

which included "opposing the catching of lobsters with nets" and "complaining to government authorities about non-local fishing activities".

4.2.8.3 Reliability

Reliability reflects consistency of measurement. In research, the term reliability can mean "repeatability" or "consistency". Therefore the measures/scales used in the questionnaire, especially the question groups where the summated scales are used it is necessary to prove that they are reliable. A measure is said to be reliable if it gives the same result each time it is used under the same condition. Cronbach's alpha is the popular way of measuring how well a set of items elicits the same responses even if the questions are repeated to the same respondent (UCLA)[20]. It is difficult to specify a single satisfactory level of reliability that should apply for all situations. The critical level for a high internal reliability among the group of variables is at least 0.60 (Bagozzi and Yi 1988) or 0.70 (Santos, 1999; Nunnally 1978; and Nunnally and Benstein 1994).

All of the survey's results are presented anonymously in tabular or graphical form. Data was analyzed using statistical software package SPSS 9.1 for windows. The results are discussed in the next two chapters.

4.3 LESSONS LEARNED

4.3.1 **One Visit Survey**

The researcher conducted only one visit to the fishing communities. He has no reason to believe that the data collected were inaccurate. However, there is, inevitably, the possibility that data collected on one day only will reflect the mood of the moment rather than the ongoing condition of the fishery. It points to the need for much closer and longer term monitoring of the industry.

[20] http://www.ats.ucla.edu/stat/spss/faq/alpha.html

4.3.2 **Concentration on the Vessel Owner**

Focusing the study on the vessel owner may lead to the neglect of crew members who also may have something to add. Their inclusion in the study might have enabled some triangulation of results and a better assessment of quantities and values as well as a different perspective on the way the fishery works.

4.3.3 **Lack of Trust**

The absence of trust among some of the fishermen is clearly a problem for the researcher and may have made the survey less accurate than it might have been with a greater degree of confidence between the State and the community.

4.3.4 **Reported Income**

Gross income was estimated from the information supplied in the questionnaire (C6 – the number of days per month combined with the sales per trip information). Moreover, as most of the fishermen are unable to read or write with any degree of proficiency, these data are only likely to be rough estimates. This finding has important long-term policy implications.

4.3.5 **The Questionnaire**

In general terms the questionnaire worked moderately well, with some useful results. However, in the light of experience it would have been preferable to deviate more from the Al-Oufi model in order to reflect the particular issues in the lobster fishery. The researcher chose to use the Al-Oufi questionnaire model with only a few modifications to suit the present study because it had already been used in Oman and was known to generate useful results.

During the study it became clear that the questionnaire did not provide much scope to build on for a negative answer. For example, question D 13 concerning resource decline did not provide scope for further discussions. Although only one percent of the fishermen

sampled gave a negative answer (i.e they did not agree that the resource had declined), it would have been useful to the study to have expanded on this and explored why they thought the resource was in a reasonable state.

SUMMARY

This chapter detailed the design of an appropriate socio-economic survey to examine the roles of the fishermen in lobster fisheries management. A detailed questionnaire was developed in order to elucidate correct responses from the fishermen as much as possible. Data collection for the study was not easy. The region is remote, there is little or no satisfactory accommodation for visitors and some of the fishermen are very protective of information. Despite these difficulties every effort was made to collect data in an unbiased manner. It should be also noted that this is the first such kind of study among the lobster fishermen that provided some useful information. It can be used to arrive at some important policy decisions. There is further scope to elaborate this study in the future to investigate some of the unanswered questions.

CHAPTER FIVE

THE SOCIOECONOMIC STATUS OF THE FISHING COMMUNITIES – RESULTS

5.1 INTRODUCTION

Coastal communities have special characteristics because of their environment and their interaction with the sea (Kartasurya, 1999). Hence, the results presented in this chapter are important in the assessment of the individual and collective behaviour of traditional lobster fishermen in the study area. Oman is very largely a Muslim Arab country and these cultural and religious features underpin, often unconsciously, the behaviour and attitudes of fishermen anywhere in the country (Al-Oufi, 1999). Some personal family questions simply cannot be raised directly amongst the older generation of relatively uneducated Omani Muslims living in remote areas, but others, such as questions about income or age, do not create offence and, in the view of the researcher, may often be answered truthfully.

The data presented are based on a cross-sectional survey (snapshot) carried out in the study area between August and December 2004 and therefore reflects the socio-economic conditions at the time of the survey, but note the qualifications at the end of Chapter 4. Among the socioeconomic aspects of the fishermen assessed are their demographic attributes, gross income, crew numbers and their assets for fishing.

5.2 FISHERMEN AGE

The average age among the fishermen sampled were 45.2 years with 75 years being the maximum and 21 years being the minimum. Table 5.1 shows the age categories of the fishermen in Al-Wusta and Dhofar regions. Table 5.2 shows the age grouping of fishermen.

Table 5.1 Fishermen Age by Region (N=201)

Category	Dhofar		Al Wusta		All Samples	
(Years)	Count	%	Count	%	Count	%
Less than 25	0	0	8	8.0	8	4.0
26 - 40	18	17.8	31	31.0	49	24.4
41 – 55	72	71.3	46	46.0	118	58.7
More than 55	11	10.9	15	15.0	26	12.9
Total	101	100.0	100	100.0	201	100.0
Mean	47		44		45.2	
Std.Deviation	7		12		10.1	

Questionnaire: Section 5, J 70

Table 5.2 Frequency of Age Groups of Fishermen in the Study

Age Group (in Years)	No. of Fishermen in the group	Percentage %
20-24	4	2.0
25-29	15	7.5
30-34	11	5.5
35-39	22	10.9
40-44	**25**	**12.4**
45-49	**55**	**27.4**
50-54	**33**	**16.4**
55-59	**20**	**10.0**
60-64	9	4.5
65-69	6	3.0
70-74	1	0.5

Questionnaire: Section 5. J 70

On the whole, two thirds of the Omani population is under 30 years of age (Census 2003[21]), so it is clear from this data that the fishermen in these two regions are in the older age group. However, the age ranges for crew members were not collected and these may reflect more accurately the age distribution for the population as a whole.

[21] http://www.moneoman.gov.om/mone/popultation.htm page accessed on 17/06/2006

5.3 EDUCATION

The results show that majority of fishermen (53.7%) do not have formal education. Only 12.9% have reached secondary education. Table 5.3 shows the details of education attainment of fishermen in the study area.

Table 5.3 Education Attainment of Fishermen (N = 201)

Education attainment (Years)	Dhofar		Al-Wusta		All Samples	
	Count	%	Count	%	Count	%
Illiterate	56	55.4	52	52.0	108	53.7
1 - 6	10	9.9	21	21.0	31	15.4
7 – 9	27	26.7	9	9.0	36	17.9
10 – 12	8	7.9	18	18.0	26	12.9
Mean (Education Years)	3.8		4.2		4.0	
Std. Deviation	4.5		4.9		4.7	

Questionnaire: Section 5, J 72

5.4 HOUSEHOLD SIZE

The majority of the fishermen sampled belonged to medium (6-10 members) and large (11-15 members) family categories. Together, these groups accounted for 70.8% of the fishermen sampled. Table 5.4 shows the data for household size among the lobster fishermen.

Table 5.4 Household Size (N = 201)

Size Category	**Dhofar**	**Al Jazir**	**All Sample**
Small (1 – 5)	11.1	33.0 %	22.1
Medium (6 – 10)	39.4	47.0 %	43.2
Large (11 – 15)	40.4	15.0 %	27.6
Very Large(› 15)	9.1	5.0 %	7.0
Mean (Members)	10.2	7.8	9.0
Std. Deviation	4.0	4.2	4.3

Questionnaire: Section 5, J 71

5.5 OCCUPATIONAL STRUCTURE

Table 5.5 shows the percentage of fishermen family members with a permanent job. Table 5.6 shows the results for the question whether fishermen face difficulty finding alternate jobs.

Table 5.5 Family Members with a Permanent Job as Percentage of Family Size

Category	Dhofar		Al-Wusta		Total	
% range workers / family	Count	%	Count	%	Count	%
Zero Working Members	84.0	83.2	93	93	177	88.1
1 – 10 %	6.0	5.9	3.0	3.0	9.0	4.5
11 – 20 %	7.0	6.9	3.0	3.0	10.0	5.0
More than 20%	4.0	4.0	1.0	1.0	5.0	2.5
Total	101	100	100	100	201	100

Questionnaire: Section 5, J 74

Table 5.6 Difficulty Finding Another Job

Question	Yes	No	Not Sure	Total
Is it easy to find another job?	7	184	3	194
	3.6%	94.8%	1.6%	97%

Questionnaire: Section 6, J 81

5.6 CREW STRUCTURE

In the present study, the majority (54.2 %) of fishermen operate with two crew members closely followed by a crew structure of 3 members (44.8%). Table 5.7 shows the distribution of crew strength among lobster fishing boats.

Table 5.7 Crew Structure

No. of Crew	Frequency	Percentage
2	109	54.2
3	90	44.8
4	2	1.0
Total	201	100

Questionnaire: Section C, C 5

5.7 FISHING INCOME

Table 5.8 shows the estimated gross income for the lobster fishermen in the study area.

Table 5.8 Reported Annual Gross Income of fishermen from Fishing

Income	Dhofar		Al-Wusta		Total	
OR	Count	%	Count	%	Count	%
Less than 3000	10	9.9	27	27	37	18.4
3000 – 5000	63	62.4	56	56	119	59.2
More than 5000	28	27.7	17	17	45	22.4
Total	**101**		**100**		**201**	
Minimum		1800		1800		1800
Maximum		12600		7920		12600
Mean (RO)		4548		3860		4205
Std. Deviation		1630		1228		1482

Questionnaire: Section 5, J 76

5.8 FISHING CRAFTS AND GEARS

These data were analyzed and details given briefly in the following paragraph. In the study, more than 80% of the fishermen used 7-meter boats followed by 8% using 5.75-meter boats. The age of the boats was mostly less than 10 years (70%). More than 90% of the boats used 40-hp outboard engine. Table 5.9 shows the length of boats in lobster fishing.

Table 5.9 Length of Boats

Category	Dhofar		Al Wusta		All Samples	
(meter)	Count	%	Count	%	Count	%
4.5 - 6	24	23.8	3	3.0	27	13.4
6 - 7	72	71.3	93	93.0	165	82.1
Above 7	5	5.0	4	4.0	9	4.5
Total	101	100	100	100.0	201	100.0
Mean	22		23.1		22.5	
Std.Deviation	2.1		2		2.1	

Questionnaire: Section B, B 1

Table 5.10 shows the boat age group and Table 5.11 shows the engine horse power in the lobster fishing boats.

Table 5.10 Vessel Age Group

Vessel Age	Dhofar		Al-Wusta		Total	
Years	Count	%	Count	%	Count	%
Upto 10 years	61	60.4	81	81	142	70.6
More than 10 years	40	39.6	19	19.0	59	29.4
Total	101	100.0	100	100.0	201	100.0

Questionnaire: Section B, B 1

Table 5.11 Engine Horse Power

Category	Dhofar		Al Wusta		All Samples	
(HP)	Count	%	Count	%	Count	%
1 – 39	0	0.0	2	2.0	2	1.0
40 – 60	101	100.0	95	95.0	196	97.5
61 – 75	0	0.0	3	3.0	3	1.5
Total	101	100.0	100	100.0	201	100.0
Mean	44.8		46.1		45.4	
Std.Deviation	8.6		10.4		9.5	

Questionnaire: Section B, B 2

5.9 DISCUSSION OF SOCIO-ECONOMIC ISSUES

In this chapter, the researcher aimed to support his arguments by way of a survey among the lobster fishermen in Al-Wusta and Dhofar regions. As noted earlier, the questionnaire approach presented some difficulties, because of the sensitive character of some of the respondents, especially from the Al Jazir area. Apart from carefully designing the questionnaire, it was necessary for the researcher to interact with them more closely during the survey to secure the most accurate information.

5.9.1 Fishermen's Age

This study found many similarities with an earlier study conducted in the Al-Batinah region by Al-Oufi (2001). In the present study also, the largest group of fishermen are in the older age category (41 – 55 years), which accounted for 58.7% overall and in Dhofar alone this category represents 71.3% of the fishermen sampled. This age group was followed by the middle age group (26 – 40 years) that accounted for 24.4% of the active fishing population. Thus the age profile is considerably older than that for the Omani population as a whole.

Coincidentally, a survey conducted in St. Georges Bay, Nova Scotia, Canada, the age of the lobster fishermen were almost identical with 23 and 79 years being the lowest and the oldest age respectively with an average age of 49 years (MacInnes, 1998). The mean age of fishermen in the Al Batinah region during a study conducted in 1979 was 35 years (Pollnac et al., 1984) but this has risen to 44 years by 1999 (Al Oufi 2001). Current trends suggest that fewer young people are entering the fishing profession. More than 53% of the fishermen are above 45 years old.

A shortage of young Omanis (nationals) being willing to enter the fishing industry may well lead to expatriates being hired for lobster fishing. This might make it harder to find solutions to fisheries management, as the expatriate interest is often to maximize income in the shortest possible time before returning home.

5.9.2 Education

This is a very important demographic variable that can influence the way fishermen perform their fishing activities. It might be assumed that experienced fishermen with a higher level of education may appreciate the consequences of over fishing and understand the need to protect the resources in contrast to those fishermen with little formal education.

Education in Oman is classified into three levels: Elementary (6 years), Lower Secondary (3 years) and Secondary (3 years). The results indicate that majority of the fishermen are illiterate with just 12.9% of the fishermen being educated to secondary level (Table 5.2). It should also be noted that none of the fishermen received higher education. This contrasts sharply with the survey among lobster fishermen in St. Georges Bay in Canada, where the fishermen had varied levels of education including graduation. The mean educational level in that study was grade 11 (MacInnes, 1998). However, that study did not correlate any relationship between the education level and state of lobster fishery.

5.9.3 Household Size

Another demographic variable studied was the household size. The majority of the fishermen sampled belonged to medium (6-10 members) and large (11-15 members) family categories. This is due to the fact that Omani families are often extended, including the respondent, his wife, parents, children and even brothers and their families sharing a common house and meals (Al-Oufi, 1999). However, in the present study, very large families accounted for 7% of the fishermen sampled. The study suggests that just one or two of the family members contribute to the household income. This requires the fishermen to earn consistent income all through the year and without other means of income, they are dependent on their catch of lobsters through out the year, especially in Al Jazir area.

5.9.4 Occupational Structure

In Oman, extended family structures normally imply that several family members contribute to the family income. In this case 88% of the family members did not have a permanent job leaving just 12% (Table 5.4) of the family members contributing to the family income. The fact that a majority reported finding it difficult to secure another job (Table 5.5) is consistent with a picture in rural areas of Oman with significant unemployment levels. This is a pattern of employment which a revitalised fisheries policy might address.

5.9.5 Crew Structure

It was observed during the survey that the crew members often included expatriate fishermen, which is illegal because fishing is an occupation reserved for Omani citizens. Table 5.6 shows the reported crew numbers in both the Al-Wusta and Dhofar regions. 97% of the fishermen had a crew structure of two or three persons in each boat. Further investigation into the role of expatriate labour and the reasons for Omanis failing to take up this occupation is still required, but given the national Omanization policy this is evidently a major issue for the fishery. Observations in the Al Jazir region showed that many expatriates were illegally employed as fishermen.

5.9.6 Fishing Income

In the present study, the majority of fishermen sampled are earning more than RO 3000 annually from fishing. Although, this is much higher than the income levels (from fishing) recorded for the Al-Batinah region (Al-Oufi, 1999), it should be noted that a significant number of other family members also contribute to the family income in that region. Further, agriculture is widely followed in Al-Batinah in addition to fishing, while fishing is the main source of income for those in the study area, especially in Al-Wusta.

Interestingly, the fishermen in Dhofar region appear to earn a much higher income than the fishermen in Al-Wusta, supporting the researcher's view that due to continued use of

nets, the lobster fishing in Al-Wusta region has been reduced significantly in recent years. Although, the lobster fishery in the Dhofar region is also much reduced, it still continues to produce higher landings of lobsters compared with Al Jazir (Table 2.2, Chapter 2). Consequently, the fishermen in this region earn more income. It is also interesting to note that the minimum income level (RO 1800) of individual fishermen in this region is still higher than the national minimum annual wage of RO 1440 (Source: Ministry of National Economy).

5.9.7 Fishing Crafts and Gears

The crafts and gears used in the lobster fishing are fishing boats, outboard motors, traps and nets. In the present study, among the fishing gears, use of nets seems to have played a crucial role in the state of fishery. As noted in chapter 2, nets are prohibited in lobster fishing but are the prime mode of fishing (Appendix - 1) particularly in Al – Wusta region due to operating conditions and the inefficiency of traps introduced in 1980s to catch lobsters.

In the present study, data were collected with regard to the age, length and power of boats used for fishing. Another significant finding was that fishing gears have not changed much for the past 15 years in spite of declining catch levels. This is in contrast to other fisheries where fishing gears have improved as catch levels declined (RDA International, Fisheries Statistics, 1988).

The fishing crafts and gears include boats (7 meter), outboard motor (40 Hp) and nets/traps. In spite of declining stock levels, the fishermen have not undertaken any improvements in their fishing gears for more than a decade. This is probably due to their local knowledge and belief that the lobsters do not move into deeper areas and thus there was no need to invest in improving fishing gears. It may be also due to the fact that the fishermen are aware that they can cover productive lobster grounds with existing boats and engine sizes. The only change or addition of gear by the fishermen has been the use

of more destructive nylon net that may have increased their catch but worsened the situation.

This contrasts with the kingfish (*Scomberomorus commerson*) fishery, in which the fishing crafts and gears have changed over time from 7 – 10 mt boats to 10 – 15 mt boats; 50 – 70 Hp engines to 230 – 480 Hp; 10 – 15 nets per boat to 30 – 45 nets per boat; crew structure of 4 – 7 people to 7 – 13 people etc. All these changes have taken place because of a substantial reduction in the landings of kingfish from over 27,784 tons in 1988 (RDA International, Fisheries Statistics, 1988) to just 2,760 tons in 2003 (Ministry of Agriculture and Fisheries, 2003). To compensate for the declining catches the Sharqia region fishermen venture beyond the Oman border to Yemen to catch sharks and yellow-fin tuna by using mid water bottom line besides drift nets for kingfish.

Fonteles-Filho (2000) stated that, following the signs of stock depletion and low catch rates, a rapid fishing effort increase was noted in the Brazilian lobster fishery. As the known distribution areas of lobsters were undergoing severe fishing pressure, the fleet moved out to more distant, unexploited fishing grounds. This expansion of the fishing area was accompanied by a change in fishing gear and craft as well, more suitable for offshore fishing. Larger, swifter boats, and different types of more effective gears came into use. Unlike the Brazilian experience, Oman's lobster fishermen have retained similar gears. According to the informal research conducted in this study alongside the formal survey fishermen believe that the lobsters are available in the near shore during spawning after which they disperse widely to deeper waters and are no longer readily available for capture.

SUMMARY

The overall picture generated by the survey may be summarised as follows:

- Ageing fishermen, above the Omani average
- Largely illiterate, accurately reflecting the characteristics of the older Omani population

- Family sizes vary considerably
- The fishermen on the whole use small open vessels, with a crew of two or three people
- Outboard engines – 40 HP Yamahas are the norm.
- Much illegal employment of expatriates
- Frequent illegal use of nets to catch lobsters.

CHAPTER SIX

AN ASSESSMENT OF THE ATTITUDES OF THE FISHERMEN

6.1 THE ATTITUDE OF FISHERMEN TO MANAGEMENT ISSUES

In the survey, the researcher investigated both socio-economic status and attitude of lobster fishermen to management issues. The results show that the fishermen are aware of the resource decline, the causes of the decline and even the consequences of decline. However, for economic and other reasons, they continue to maximize their return.

6.2 PERCEPTION OF RESOURCE STATUS

Table 6.1 and 6.2 show the results for the fishermen perception of resource status. Table 6.3 shows that 98% of fishermen report finding that their fishery is in decline.

Table 6.1. Perception of Resource Status

Statements	Responses		
	Agree	Indifference	Disagree
E20. Your lobster catch per trip declines	187 93.0%	12 6.0 %	2 1.0 %
E21. The large lobsters are difficult to find or catch	194 96.5%	7 3.5 %	- 0 %
E22. We need to spend longer hours looking for lobsters then we used to	201 100 %	- 0 %	- 0 %
E23. The percentage of trash fish in your daily catch has increased	198 98.5 %	3 1.5 %	- 0 %

Questionnaire: Section E

Table 6.2 How do you describe the problem of lobster fishery decline?

Response	Count	Percentage
Extreme	84	41.8
Severe	83	41.3
Moderate	31	15.4
No Problem	2	1.0
No response	1	0.5
Total	201	100.0

Questionnaire: Section D, D 14

Table 6.3 Do you think the fishery of your community is declining?

Response	Count	Percentage
Yes	197	98.0
Not sure	2	1.0
No Response	2	1.0
Total	201	100.0

Questionnaire: Section D, D 13

6.3 THE CAUSES OF OVERFISHING

Table 6.4 shows the reasons for overfishing according to lobster fishermen. Twenty eight percent (28.4%) of fishermen told usage of nets as the cause of overfishing among other reasons and topped the table.

Table 6.4 What makes lobster resources decline?

Response	Count	Percentage
Using Nets	57	28.4
Commercial vessels	44	21.9
Not enough observers from Ministry	26	12.9
Not following rules	25	12.4
Fishermen from other villages	10	5.0
Fishing out of season (breeding)	7	3.5
Fisheries Dept. is not providing traps	4	2.0
Total	173	86.1
Missing	28	13.9
	201	100.0

Questionnaire: Section D, D 17

Table 6.5 Causes of Overfishing

Statements	Responses		
	Agree	Indifference	Disagree
F24. lobster resources decline if too many vessels are operating in the same area	198 98.5%	1 0.5 %	2 1.0 %
F25. lobster resources decline if all vessel are large in size	201 100 %	- -	- -
F26. lobster resources decline if all vessels use high horse-powered engines	198 98.5%	2 1.0 %	- 0 %
F27. lobster resources decline if all vessel employ a large number of nets	201 100 %	- -	- -
F28. lobster resources decline if fishermen use Destructive gear	201 100 %	- -	- -
F29. lobster resources decline if fishermen increase their fishing time per trip	201 100 %	- -	- -

Questionnaire: Section F

6.4 THE CONSEQUENCES OF OVER FISHING

Table 6.6 The Consequence of over fishing

The Items	Responses		
	Agree	Indifference	Disagree
G30. Your fishing area becomes further away from your village	118 58.7%	31 15.4 %	52 25.9 %
G31. Your fishing hours become longer	199 99 %	1 0.5 %	1 0.5 %
G32. Your fuel consumption increases	187 93.5%	9 4.5 %	5 2.5 %
G33. Many fishing areas are barren	199 99 %	2 1.0 %	- -
G34. You have to use more fishing gears to catch lobsters	201 100 %	- -	- -
G35. Your income from fishing declines	60 29.9 %	- -	- -

Questionnaire: Section G

6.5 COLLECTIVE ACTIVITIES OF FISHERMEN

It was important for the study to assess the attitudes of fishermen towards cooperation. The researcher was anticipating that at least part of the solution to the problems in the fishery was through collective action to a greater or lesser degree. The recommendations would then depend on the outcome of the study. Tables 6.7 and 6.8 demonstrate a limited degree of cooperation among themselves, although there appears to be some evidence of alienation from the institutions of the State.

The Fishermen Cooperation Index (Table 6.8) was an interval measure and the score ranged between 0 and 12. Analysis shows that with a mean level of 8.24 and standard deviation of 1.85 the fishermen indicate willingness to cooperate. The Cronbach's alpha coefficient for the 12 items is 0.65, which shows the reasonable internal consistency of the questions in the index. The cut off value for alpha is 0.6 (Bernstein & Yi, 1988).

Table 6.7 Methods followed to avoid net entanglement problems

Method	Frequency	Percent
Set the traps/nets at a distance from other fishermen nets	156	77.6
Do Nothing	42	20.9
Commercial vessels shouldn't fish in fishermen areas	3	1.5
Total	201	100.0

Questionnaire: Section I, I 46

Table 6.8 Fishermen Cooperation Index

List of attitude Items	Responses	
	Yes	No
M88 Returned under-sized lobster into the sea when caught in your net	200 99.5 %	1 0.5 %
M89 Set your nets/traps at a distance from other fishermen gears	201 100 %	--
M90 Inform on colleagues who break the fishing rules	15 7.5 %	185 92.0 %
M91 Attend workshops arranged by the Ministry of Agriculture and Fisheries	105 52.2 %	95 47.3 %
M92 Renew your fishing licence and boat licence	149 74.1 %	49 24.4 %
M93 Speak to the head of the tribe about the problem of your fishery	177 88.1 %	24 11.9 %
M94 Discuss fishing problems frequently with more than one fisherman	184 91.5 %	17 11.9 %
M95 Participate in a group to resolve conflicts in fishing	150 74.6 %	51 25.4 %
M96 Persuade others to follow fishing rules	151 75.1 %	50 24.9 %
M97 Visit the Governor office to complain about other fishermen activities in fishing	131 65.2 %	70 34.8 %
M98 Oppose catching lobsters with nets	190 94.5 %	11 5.5 %
M99 Own artificial reefs (number of reefs)	4 2.0 %	197 98.0 %

Questionnaire: Section M

6.6 RESULTS, SUMMARY AND DISCUSSION OF ATTITUDES

6.6.1 The Attitude of Fishermen to Management Issues

The questionnaire was prepared so as to elucidate what the fishermen perceive about the state of fisheries in their area. Problems of resource use that constitute common dilemmas are those situations in which fishermen continue to harvest at a sub-optimal level even though an optimal level can be reached collectively (Al-Oufi, 1999). The main task here was to evaluate fishermen's awareness of the problem they are encountering in their fishery. Hence, the questionnaire was designed to identify the response of fishermen to a range of indirect questions related to fishery status (Table 6.1).

Ninety three percent (93%) of the fishermen sampled agreed with the statement that their lobster catch per trip was declining. All of the fishermen sampled agreed with the statement that they had to spend longer hours at sea catching lobsters than in earlier years. For example, the fishermen perceived the problem of fishery decline as severe or extreme and agreed that fishing gears do influence the state of fisheries in their area.

The results showed that over 95% of the fishermen sampled were aware that lobster resources in the area are declining. Interestingly, all the fishermen sampled in Al-Wusta region completely agreed with all statements with regard to state of their resources, where the lobster fishing has declined to very low levels. Table 6.2 shows that more than 82% of the fishermen described the situation as severe or extreme. These results show that the fishermen are aware of their declining fisheries.

6.6.2 Causes of Overfishing

The majority of fishermen responded that the use of nets was the main cause of resource decline followed by commercial fishing vessels (Table 6.4). This supports the researcher's observation that nets are used for catching lobsters although there are no officially published reports to confirm this situation.

Considering the sensitive nature of the topic, questions were set to bring out natural response of the fishermen. The questions were not specific to what the individual

fisherman does but a generalised statement encouraging the fishermen to make a response that revealed the causes of overfishing. Again, the questions were just statements to which the fishermen were asked to agree, disagree or indifferent. The statements presented to the fishermen and their responses are shown in Table 6.5, which demonstrates some understanding of the impact of fishing effort, in its various dimensions, on fisheries resources.

Interviews conducted among lobster fishing community at Beyla and Kulule of Puntland in Somalia revealed similar results with all of the fishermen agreed to the fact that their lobster catches declined considerably (Fielding and Mann, 1999). The main reasons for the decline were: increasing fishing effort (38%), commercial foreign trawlers (22%), fishing through out the year (20%), catching of berried and juvenile lobsters (9%) and other reasons (11%).

Among the causes of overfishing, almost one third of fishermen interviewed accepted that use of nets has depleted the lobster resources closely followed by commercial vessels (22%). All the fishermen interviewed agreed that destructive fishing gears contribute to the lobster stock decline. In spite of this awareness, the over fishing continues to occur since there is no systematic procedures to monitor and regulate the fishery in a sustainable manner.

6.6.3 Consequences of Overfishing

Further questions were set to investigate whether the fishermen understood the exact consequences of overfishing (Table 6.6). Again, the questions were presented indirectly as statements to generate a response from the fishermen.

The fishermen were in agreement with all statements except to that in relation to the fishing area becoming more distant from home. Only 58% of the fishermen agreed with this statement while 25% disagreed. The reason may be due to the fact that lobsters are mostly caught in the continental shelf close to shore. While the fishermen agreed that the lobster resources declined, they did not think that lobsters moved to deeper waters or to

other areas. However, this needs to be investigated scientifically with regard to lobsters' habitat preferences, seasonal movements and so on.

6.6.4 Collective Activities of Fishermen

Questions in this section are more direct and the responses were quite positive. Table 6.8, M96 shows that over 75.1% of the fishermen said they will persuade others to follow fishing rules while 24.9% declined to do so. Although the majority of the fishermen are aware of the causes of conflicts, in reality conflicts arise particularly due to the fact that stocks are depleted and most of them are desperate to catch what they can. The response to question M97 shows that 65% of the fishermen visit the Governor's office to complain about other fishermen activities and most of them are related to conflicts.

6.6.5 Policy Implications

There is almost universal agreement that the cause of overfishing is excessive fishing effort (Table 6.5) but less documented on the detailed factors as to why (Table 6.4). This emphasises the need for concrete and well-founded extension and regulation of the fishery. An important policy issue that requires further discussion with stakeholders is the role of collective action in the improvement of fisheries management. Collective opinions that might lead to a strong form of co-management are not universal. So there is much work to be done in this direction. The suggestion in chapter 7 is that the tribal leaders are probably a suitable starting point for the achievement of improvement of collective responses.

SUMMARY

In this chapter the attitudes of fishermen to lobster management issues collected during the survey were discussed. 93% of the fishermen sampled agreed that catch per unit effort was declining and 95% of the fishermen were aware that the lobster resources were declining. The majority of fishermen believed that the use of illegal nets was the main cause of stock depletion followed by commercial fishing vessels.

CHAPTER SEVEN

LOBSTER FISHERIES MANAGEMENT – RECOMMENDATIONS FOR AN IMPROVED REGULATORY FRAMEWORK

7.1 INTRODUCTION

Evidence presented in previous chapters clearly shows that the spiny lobster resource in Oman is significantly overfished with catches generally declining. As discussed in Chapter 2, the Omani government has previously implemented a number of regulatory measures essentially as a reaction to problems. Al–Bahrani (1995) and Al–Hafidh (1999) reported that the management measures implemented for the abalone fishery were taken similarly as a reactive approach to deal with problems rather than as a planned management programme, based on sound biological principles.

7.2 RECOMMENDATIONS FOR LOBSTER FISHERY MANAGEMENT

The major recommendations arising from this study based on the researcher's experience, published data and current project results are as follows:

1. Biological, environmental, social and economic knowledge must be acquired and integrated into long-term management plans.

2. All stakeholders – scientists, policy makers, fishermen, processors and traders, must be engaged in the development and implementation of a lobster management plan.

3. Public awareness of the benefits of a sustainable lobster fishery must be developed through effective educational programmes.

In order to achieve each of the above major recommendations the following issues should be addressed.

7.2.1 **Financial Resources**

Good sustainable fisheries can be developed with continuous ongoing investment by the Government in compliance, research and management of the fishery commensurate with the value of resources fished. The costs of management of the fisheries and in particular, the compliance costs have increased significantly in response to a more complex management environment.

In 2004, the value of all Oman fisheries was reported to be about R.O. 75 million (US $193 million). As a measure of annual expenditure, the Western Australia Fisheries Department spends about 2.3% of the gross value of lobster fishery to ensure adherence with fishing rules (Morgan, 2002). Additional funds are allocated for R&D, policy and programme management and levies for fisheries development fund. The total cost of management is now collected from potholders as a license fee and administered by the Fisheries Department.

The above funding levels necessary to enforce regulatory frameworks in Australia cannot be readily applied in Oman. It should be noted that the Omani government does not earn any direct revenue from traditional fishing. However, there is revenue from commercial fishing and the earnings (approximately R.O. 5 million/year) goes directly to the Ministry of Finance. A part of the revenue is diverted to a research fund (common for both agriculture and fisheries). It is clear however that the Oman Government requires a greater allocation of funds than at present in order to initiate effective fishery management. Additional sums are required for achieving management strategies mentioned in this submission. Without a generous financial commitment, Oman will not restore its high value fisheries. This in turn will see the continuance of resource over-fishing, reductions in fishing revenue and lost employment opportunities.

The objectives for Oman are to ensure sustainability of the lobster resource and to maximize the economic and social benefits of the fishery. Under these two objectives, the proposed management plan addresses the following issues.

7.2.2 **Surveillance and compliance programmes**

Strategically located fisheries offices are essential to manage compliance and surveillance in conjunction with fishery surveys and also to operate as information centres. The offices should be controlled by an independent directorate headed by a fisheries officer experienced with implementing modern fishery management methods in similar regions. This directorate should be a critical component of the overall fisheries management plan reporting directly to the minister and given support by the Ministry of Interior and Royal Oman Police (ROP) to regulate the fishery.

The above requirement is essential for the Al-Wusta & Dhofar regions, which are the most productive areas for lobster and shrimp fisheries (Mohan and Al-Amri, 1998). To date, this region has been virtually ignored in terms of effective fishery management apart from general infrastructure development of the region. There is no dedicated fisheries management office operating in the area indicating totally ineffective control of the fishery sector.

Al-Kharousi (1999) gave a detailed account of fisheries monitoring, control and surveillance in the Sultanate of Oman. Although, she described various issues regarding the available resources, these are not implemented effectively. Any proposed compliance programme should include a complete set of rules and regulations with regard to inspection at various points of lobster trade and promote prosecution in case of abuse. Although cases have been recorded and confiscation of materials reported (Anon[11], Oman Tribune, 21 February 2006), these cases are very few and had no serious impact on the fishermen conduct. Table 2.3 in Chapter 2 reveals the quantity of confiscated lobsters due to fishing out of season, berried and under size totalling just about 38,000 kg in 4 years.

Ideally for effective compliance, inspections might include:

- Land and sea patrols
- Auction place, shore, fish market, factory, vehicle, fish trader and restaurant inspections

- Transport permits
- Routine inspection of fishermen's licence.

In the implementation phase the focus might be narrowed.

The compliance programme should also include:

- Preparation of an inspection manual
- Compilation of legislation
- Prosecution policy guidelines setting limits for warnings, confiscation of catch and gear, court prosecution for each offence
- Develop skills in surveillance, prosecution, conflict management and extension training for fisheries staff.

7.2.3 **Research programmes**

As mentioned earlier, research should focus on both biology and stock assessment in order to contribute to the future management success of the fishery. The ideal research needs are as follows:

- Collection of biological data on growth, mortality of undersize and berried females from fishing and monthly seasonal variation in egg production
- Determination of the geographic distribution of spiny lobsters in the Sultanate of Oman
- Measurement of oceanographic factors regulating recruitment, movements and migrations
- Establish an effective lobster catch and effort data collection network
- Improve lobster pot design that allows escape vents for undersize lobsters.

7.2.4 Liaison between the Government and lobster fishermen

A fishery cannot be managed effectively without the cooperation and participation of fishers to make laws and regulations effective (Pomeroy and Berkes, 1997). While fishermen continue to ignore fishing regulations, little can be done to improve management of the lobster fishery. Increased inspection and prosecution will lead to compliance with the fishing laws but these alone will not solve all management problems. The cooperation and support from the fishermen is crucial and chapter 6 shows that many fishermen are aware of the problems. Fishers participation in management can provide a wealth of local or indigenous knowledge to supplement scientific information, to help monitor the resource and to improve overall management (Pomeroy, 1995). Many fisheries management arrangements failed to coordinate and restrain fishers, leading to depleted resources and conflicts (Pomeroy and Williams, 1994). Even a well-planned awareness programme with strict surveillance will prove counter productive if not presented sensitively.

To prevent further depletion of fishery resources in Oman, fishery management measures should be communicated through tribal leaders, who probably have the greatest influence over local fishermen. These tribal leaders should be taken into confidence since their support of fishing rules in local communities can be a powerful compliance tool (Rogers, 2002). This strategy together with the introduction of welfare schemes such as incentives for compliance, education, awareness, subsidies on pots and government subsidies for job diversification will be helpful in winning the support from the fishermen. It should be emphasized to fishermen that it is a national duty to protect these valuable resources and those who excel in this task should be recognized and rewarded with incentives. This could include priority in the fishing license allocation when such systems are introduced. Though this approach is a slow gradual process, it will be effective if properly implemented.

7.2.5 **Social and economic benefits for traditional fishermen**

The management system will stabilize the catches and fishing-capacity and result in a wealthy and stable fishery for the benefit of the fishermen. This will improve their social status and increase their economic benefits for years to come. However, the fishermen will need to be convinced of this.

7.2.6 **To increase the value of catch taken at all levels of distribution**

There should be a greater emphasis on product quality in Oman through the involvement of processors and traders. This should be done via awareness programmes designed to maximize product quality. This can include quite simple measures such as provision of ice production units at important fishing villages. Processors can play an important role for supplying quality products. Another important and effective measure will be encouraging and supporting the fishermen to move towards supplying a live product market instead of just frozen tails. These measures will support compliance and recovery of the fishery and generate added value to the catch.

Training in quality enhancement of lobster catches through better post catch handling techniques could also contribute to improved returns from the fishery by specifically targeting the high value niche markets requiring fresh and live lobster supplies. This will also encourage fishermen to use traps to land lobsters unharmed. Miller (2003) noted that trap-caught lobsters returned to sea remained healthy and close to where they were caught. He further estimated a 15% annual loss in value due to mishandling of the catch in Nova Scotia. Table 7.1 summarises the present status of the lobster fishery and the researcher's recommendations for effective management.

Table 7.1 Lobster Fisheries: Present Status and Recommendations

Present Status of Lobster Fishery	Recommendations
No consultation with stakeholders with regard to management issues.	Establishing a management plan in due consultation with all stakeholders of the fishery.
Poor monitoring and surveillance.	Effective monitoring at points of trade including, possibly, at-sea monitoring, border points and auction houses.
Studies on biology are outdated.	Focused research on biology, ecology and life history of lobsters.
Stock assessment limited to statistical data collection, biometry, tagging (yet to begin) etc.	An improved statistical collection system including data on fishing effort is essential. In addition a complete survey of continental shelf by boats equipped with colour echo sounder and under water video coupled with efficient data collection is sensible.
Management measures addressing short-term issues.	Comprehensive management plan, developed in consultation with all stakeholders, to address both short and long term issues. Collaboration should be sought from neighbouring countries in the task
Fishermen not realizing the potential implications of using destructive nets.	Awareness raising programmes aimed at educating fishermen about benefits of sustainable fisheries. Effective use of tribal leaders to communicate fishery laws.
Ministry lacking skilled and experienced staff.	Recruit staff with necessary skills, experience and commitment for fisheries management on par with advanced countries and gradually train local staff.
Poor handling of lobsters resulting in quality problems.	Assistance to fishermen to improve post harvest quality by involving processors in the task of supplying high value products to market.
The most fertile region ignored in terms of fishery development.	Development schemes aimed at ancillary industries, independent regional fisheries office, welfare programmes etc.

7.3 IMPLEMENTATION PLANS

The following section prioritizes the key issues that should be focused upon in the near future in order to arrive at a comprehensive management plan that is effective and acceptable to all participants. There are two major requirements:

7.3.1 **The establishment of an independent directorate**

As previously noted in this submission, the coastal belt extending from South of Masirah to Sadah is the most fertile in Oman with regard to fishery resources. At present, only representative offices of the Ministry of Agriculture and Fisheries operate in this region with a fisheries division. This divisional office merely oversees routine administrative jobs like renewal of fishing licenses, collection of statistical data and is also supposed to undertake monitoring and surveillance. However, with just a handful of support staff, this office is unable to perform even its basic functions.

Establishing an independent fishery directorate in this region will go a long way toward achieving the objectives of the Ministry. The key is the recruitment of skilled people with the appropriate powers in the directorate, which must be independent reporting directly to the Minister. The directorate must be headed initially by an expatriate with long-standing practical and proven experience in fishery management. This officer would have to be provided with the appropriate authority and budget to succeed in reversing the current situation.

This will bring new ideas and directions to Oman and will be a key factor for the further course of action. Under a competent leader, the Ministry should then analyze the issues and take steps accordingly. The immediate issue will be the allotment of funds to this office and seeking support from other ministries, especially the Ministry of the Interior and Royal Oman Police (ROP) for monitoring and surveillance.

7.3.2 **Action plan**

The next step should be analyzing the present status of core issues and planning the future course of action. The immediate concern should be on recruitment of support staff for different management strategies – biology, stock assessment, data collection, monitoring and surveillance, licensing and permit control and extension. Once this is completed, the next priority will be planning for each department focusing on current status, future course of action and funds required, including training of local staff. Finally, it will be necessary to integrate all the plans to establish a comprehensive plan to meet the overall objectives.

7.3.2.1 *Focus on biology*

The present management regulations involving trap fishing, limiting the fishing season, protecting egg-bearing females and lobsters below minimum legal size may have had some influence in protecting the resource. However, without adequate stock-recruitment information, it is difficult to determine the exact impact of these regulations as effective management tools (Campbell, 1989). Important biological questions on stock and recruitment are yet to be answered.

As stated in Chapter 1, studies on lobster biology in Oman are both limited and dated. These studies considered some biological characteristics such as reproduction and growth. However, new studies are needed to more fully understand the ecology of Oman's lobster fishery. This is essential to formulate better management (Mohan, 1997). For example, after a detailed biological assessment, the Western Australian Lobster Management Plan imposed a maximum legal size of 115mm CL to boost the numbers of larger breeding females in order to increase egg production (Phillips & Kittaka, 2000). This will also help to reduce the dependency on one or two size classes of breeding stock apart from stabilizing the downward trend in egg production. Thus, the management plan in Western Australia has both a minimum and maximum legal size for landing lobsters.

The success of the Western Australian Rock Lobster Fishery was due to its management policies, which have been based on research programmes to understand

biology, life history and population dynamics of *P. cygnus* and in studying production models, yield per recruit, stock-recruitment processes and predicting recruitment and catch based on indexes of pre-recruit abundance and puerulus settlement (Phillips and Brown, 1989). Due to the improved management measures, the Western Australian Rock Lobster Fishery yields have been consistently above 11,000 tons for nearly two decades. Similarly, an improved understanding of the reproductive biology of Oman stocks could be a tremendous boost to future stock enhancement programmes, habitat development and possible stock enhancement ventures to support job diversification among coastal communities.

The research activities of Marine Science Center in Muscat and Salalah should complement those undertaken at the Department of Marine Science and Fisheries at Sultan Qaboos University. The scientists should seek collaboration from reputed institutes in other countries in order to ensure that the research is on par with world standards and focusing on current issues. Efforts to design pots suitable for different ecological conditions should be one of the priorities for research (Munro, 2000). Scientists should also make timely and relevant recommendations to the directorate office with regard to suitable conservation measures based on their research findings.

7.3.2.2 *Stock Assessment*

To improve understanding of the available habitat for the Oman lobster fishery, activities such as near shore transect mapping of coastal waters are required with modern coloured echo sounders combined with under water video and GPS to better define the seabed topography of lobster habitat. This will allow more precise understanding of the extent of residual lobster breeding stocks and a better estimate of current stock levels (Rogers, 2002).

Studies on biology and stock assessment should complement each other in improving the prediction of population changes (short term and long term); understanding processes and mechanisms that contribute to natural variability in populations; defining relationships between habitat characteristics and productivity; and providing alternative

management approaches (Rogers, 2002). Studies on reproductive potential by size class would reveal whether the current minimum legal size is effective in improving the stock levels. An accurate definition of the sexually mature component of the population is required for the management of any stock (Chubb, 2000). As in Western Australia, Oman could also consider both minimum and maximum legal size based on appropriate research studies.

Predicting stock size and catch of spiny lobster is extremely useful to the industry as well as to fisheries management. Puerulus collectors are now installed at several locations in Western Australia and operating successfully as a catch predicting system (R.Mohan, pers.com). The ability to predict the level of recruitment to the fishery 1 to 4 years in advance using the catch rate of pre-recruits is an important management tool for the Western Australian spiny lobster fishery (Caputi and Brown, 1986).

7.3.2.3 Monitoring and Surveillance

The inspection needs of the lobster fishery cannot be undertaken in isolation of adjoining fisheries. Unless effective inspection and prosecution arrangements are in place for the entire year, management of the fishery will be ineffective.

As stated in the Synthesis of Lobster Workshop Discussion (Anon[8], 2004), management practices such as seasonal closures, size limitations, catch quotas, gear restrictions and bans on the taking of berried females are unlikely to be adopted or effectively enforced due to much looser governance arrangements for coastal fisheries. Miller (2003) stated that Canadian lobster scientists did not favour catch quotas because of the difficulty in their enforcement. Contrary to this, in Australia measures are enforced strictly and resulted in a very healthy fishery. Though hard to implement, effective monitoring is the key for limiting violations and over exploitation of lobsters for the successful management. This will require for effective enforcement. Good management of any resource, whether terrestrial or marine, involves balancing costs and benefits of changes proposed.

Preparation of fishery logbooks based on legislation will be essential for dealing with fishery infringement cases in a fair and consistent way (Rogers, 2002). Monitoring should be done both at sea and on land. Establishing designated legally binding point of sale at important landing centres and transport permits will help reduce the offences related to trade in under sized and berried females. Support from the Ministry of Interior and Royal Oman Police (ROP) will be important in dealing with aggressive fishermen to enforce compliance. Customs officials at border posts should be trained accordingly in handling illegal lobsters. They must be aware of fisheries regulations with regard to under size, berried lobsters and fishing seasons.

7.3.2.4 *Data Collection*

Monitoring of catches and fishing efforts along with the relevant statistical analysis are the responsibility of the Department of Fisheries Statistics within the ministry. Fishery data is collected through landing reports submitted by fishery officers stationed along the Oman coast. However, this department has been very weak in providing meaningful reports (Al-Bahrani, 1995). The quality of the data is insufficient to enable calculations on the level of fishing effort with any degree of accuracy. Hence, the current data collection methods for management and stock assessment need re-evaluation.

Besides the enforcement of fishery regulations, successful management of the spiny lobster fishery will depend on an accurate database and a more precise measure of fishing effort (Phillips & Kittaka, 2000). Statistical data collection should be dependable in meeting the requirements of management and stock assessment. As the fishery is primarily located in remote areas of the Sultanate, estimates from observations on quantities landed and fishing effort at landing sites are difficult to make, particularly in the absence of the required number of data collectors. The collection of data should be more efficient in terms of catches and effort and should be made readily available for researchers. More trained data collectors should be engaged to cover the long coastline and the regional directorate offices will be supportive in this task. Creation of points of sale will make the task easier for effectively recording the data.

7.3.2.5 *Fisheries Regulation*

The regulatory measures now in place for the lobster fishery in Oman are given in detail in chapter 2. The above measures were mostly implemented based on information from lobster fisheries in other parts of the world rather than on clear scientific research of Oman's fishery. A similar approach in Mexico where minimum size regulation was introduced based on a Californian management plan was not observed by fishers who believed the minimum size limit was too high (Chubb, 2000). It was stated earlier in chapter 2 that the fishermen opposed the implementation of new fishing season, as they perceived it as interference rather than a regulatory measure.

Without positive action to reduce the mortality of undersize lobsters, serious growth over-fishing and loss of yield will continue to take place. Cushing (1975) stated that growth over-fishing is assumed to be the main cause of stock decline in long-lived species. Due to the difficulties in enforcing regulations production may be enhanced by moving the closed season based on studies of reproductive patterns. Ideally, size limits should be based on sound research designed to improve egg production and recruitment, while being enforceable and consistent with market requirements (Chubb, 2000). For example, the size limit set for Mexican west coast as that of *P. interruptus* in Baja California resulted in fishermen opposing the measure (Briones-Fourzan and Lozano-Alvarez, 1992).

Problems with regard to fishing gear discussed earlier in chapter 2 require discussion with all stakeholders to provide positive results similar to fishery management studies in Australia and North America. The efficiency of the pots used in Oman could be improved with more focused research on pot design. The Western Australian Management Plan incorporated a strict design and dimension rule for the pots and increased the escape gaps to three in every trap allowing undersize animals to escape (Phillips and Kittaka, 2000). Lyons and Hunt (1991) stated that traps are one of the most effective management tools to reduce mortalities and injuries during catch. They further added that appropriate escape gaps could eliminate confinement mortality of undersize lobsters.

The advantage of properly designed traps to catch lobsters unharmed for live export merits investigation into trap-fishing technologies. This is particularly important in the context of decreasing import trends for frozen lobsters in the Japanese market (Tsuruta and Kittaka, 2000). These authors stated that the quantity, value and price for frozen lobsters showed a declining trend but remained stable for live, fresh and chilled products. Half of the Australian production and 95% of the New Zealand production are exported live (Stevens and Sykes, 2000). CSIRO scientists (2003) stated that by moving to a live export fishery, the fishers could maintain a similar income level while catching only half the number of lobsters as live specimens which are worth twice that of frozen tails. Implementing this practice in Oman could have significant long-term benefits in stabilizing the fishery but will require financial support to implement over several years.

Initiatives in the form of improved cooperation with neighbouring countries, particularly the UAE and Yemen, could also assist in protecting the Oman's lobster fishery, which is commonly shared by these countries. For fishery management to be effective, it should be comprehensive and should include the entire region rather than just one country. This is sensible in the context that the lobsters of Oman, Yemen and Somalia are believed to be a single population (Fielding and Mann, 1999; Rogers, 2002).

Consequently, a collaborative management programme is required to manage and protect the fishery particularly since the species undergoes natural cross border migration along the coast (Fielding and Mann, 1999). The increased vulnerability to fishing lobsters undergoing breeding or spawning migrations is of particular importance to managers because of high exploitation rates on these individuals which can substantially reduce egg production as seen in Torres Strait (CSIRO, 2003). It is not possible to influence oceanic transport of larvae as palinurids cross a many geographic boundaries. However, efforts can be applied to protect nursery habitats that are essential for post larval settlement and juvenile development and can seek multinational management strategies wherever possible (Butler and Herrnkind, 2000). Similarly, regarding illegal imports of lobsters to UAE, the issue can only be resolved by joint collaboration between the two governments.

7.3.2.6 Auction System

At present there is no complete auction system in Oman for the seafood trade. The existing auction system is based on a traditional one, mostly completed at landing points without any scope for recording the data. The creation of a modern auction house system at designated landing centres would support regulation of fishing activities. Auction houses will issue a no objection certificate that will accompany each consignment certifying its legal origin. This will make the role of border officials easier in terms of identifying illegal shipments. An electronic auction house at important landing centres linked to a central auction house in Muscat will be more effective in regulating the fishery and in the collection of more relevant statistical data. Fishermen landings in more remote fishing villages should also be encouraged to bring to the nearest auction house for the above reasons. This will ensure better prices for the fishermen, more effective compliance and administration benefiting the industry through improved product quality and marketing. Following the Cuban model, the fishermen could be encouraged by the government to use holding tanks in their boats to keep the catch alive. In addition, to improve marketing opportunities through the specific targeting of seasonal fluctuations in lobster market value sea based holding pens could be constructed similar to that proved effective in India and other countries (NIOT; Phillips and Kittaka, 2000).

7.3.2.7 Extension Activities

The importance of socio-economic studies and community education programmes to convince village fishers of the value of conservation and sustainable fishing practices has been successfully demonstrated in some countries like Philippines (Anon, Synthesis of Workshop Discussion, 2004). This is one of the most important components of lobster fishery management. The tasks of the Extension Department include programmes to educate and inform fishermen and the public about fishery laws and regulations.

Creation of awareness for sustainable fisheries is difficult and time consuming. This will be particularly so in Oman since the fishermen are a tribal-based community. Consequently, the role of tribal leaders in fisheries management will be crucial. In this respect the tribal leaders must be given prominence and informed of the benefits of

sustainable fisheries. The objective should be to make each fisherman feel that he ultimately will be the gainer by complying with the fishing regulations, which are aimed at improving his own welfare through support by the Ministry.

The Ministry should involve tribal leaders and encourage their active participation in the programme through competition and suitable incentives for good compliance. The incentives should be in the form of both financial and government recognition since these tribal leaders are often concerned with social status. They can be also involved in the proposed auctioning system, so that they will appreciate the value of management measures.

7.3.2.8 Fisheries Co-management

Fisheries co-management is defined as the sharing of responsibility and authority between the government and the community of local fishers to manage a fishery (Pomeroy and Berkes, 1997). Fisheries experts now recognize that resource conflicts can be diminished and resources better managed when fishers and other resource stakeholders are more involved in management (Pomeroy, 1995). Community-based coastal resource management (CBCRM) systems have become a way to activate social processes and involve resource users in resource management (Pomeroy and Berkes, 1997). Co-management systems have emerged as a partnership arrangement using the capacities and interests of the local fishers and community, complemented by the ability of the government to bring in legislation, enforcement and conflict resolution, and other assistance. However, Pomeroy and Williams (1994) cautioned that CBCRM may not be suitable for every fishing community as many fishers may not be willing to or capable of taking on the responsibility of such systems.

It takes two parties to have co-management, and the government is a crucial partner. If co-management initiatives are to be successful, basic issues such as government legislation to establish legal rights and authority frameworks must be addressed. The establishment of an appropriate government administrative structure and an enabling

legal environment are essential to promote and sustain existing local level fisheries management systems and/or to develop new co-management systems.

One fundamental debate in co-management is whether resource users can be entrusted to manage their resources (Berkes, 1989). Unless governments and decision-makers, who implement government policy, can be convinced of the desire and the ability of users to manage themselves, not much progress can be made in co-management. The Oman Government's extension programme could be particularly relevant in the respect of supporting co-management. The extension service could be used to educate fishing communities via tribal leaders who would receive direct instruction in fishery management extension programmes.

Another novel co-management approach would be involving lobster fishermen in aquaculture. As introduced in India by the National Institute of Ocean Technology (NIOT[22]), fishermen can be encouraged to culture lobsters from pueruli or early juvenile stage in small cages. In Oman a policy might be introduced to allow collection of some wild lobster pueruli for ongrowing to market size or stock restoration purposes. This is in preference to the practice of taking undersize lobsters, which already have a good chance of recruiting to the adult fishery. This may provide opportunities for year round income to the fishermen and effectively prevents the capture of undersize lobsters as the fishermen would no longer need to sell the small size lobsters at lower prices. The role of Government would be to provide small cages and supply of pueruli from hatcheries or coastal pueruli collectors. However, this approach to fishery restoration must be based on sound biological data relating to the fishery status and may be taken up at a later stage when stock levels are healthy.

[22] Technology for Society, lobster fattening, National Institute of Ocean Technology, India.

7.3.2.9 Stock Enhancement

Spiny lobster populations may potentially be enhanced through stocking of early benthic juveniles obtained through propagation or from puerulus collectors or by the deployment of artificial shelters (Butler & Herrnkind 2000; R. Mohan, Pers.com). The importance of the lobster stock enhancement as a tool in fisheries management and various stock enhancement programmes and their status has been documented in chapter one of this submission. The researcher considers stock enhancement as an important tool for Oman not only to rebuild the stocks but also believes that such initiatives by the government will create a positive impact on the mindsets of fishermen that the government is concerned about the state of fisheries and serious about improving the situation.

Apart from the biological impact of implementing stock enhancement programmes, the psychological impact on fishermen is very important for the whole management programme to succeed as the fishermen will see government participation in rebuilding the stocks apart from just setting rules for regulating the fishery. This will help the fishermen to realize the importance of fisheries regulation and may also encourage them to adhere to the measures.

The manner in which enhancement programmes will be implemented is another critical issue that the authorities need to focus on. Considering that spiny lobster propagation is still in its earlier stages and not much success has been achieved so far with regard to larval survival rates on the sea bed, it is critical as to how such a programme is accomplished. One good starting point may be the implementation of artificial shelters.

Determining the appropriate type of shelter to be deployed is a prerequisite step in situations where shelter enhancement may be desirable. The role of artificial shelters is discussed in Chapter 1, particularly its effectiveness in concentrating populations and hence in increasing vulnerability to predation and increased fishing pressure.

Again the implementation of the artificial shelters should be based on a detailed understanding of the fishery and selected sites otherwise the procedure can be

counterproductive and lead to failure of the fishery (Phillips and Kittaka, 2000). As Munro and Bulgos (1995) explained, artificial reefs can result in social and economic benefits where fisheries are well regulated but lead to further over-fishing if uncontrolled. Waltemath and Schirm (1995) further stated that if catches exceed the maximum reproductive potential of the stocks, then it can be concluded that the artificial reefs are primarily functioning as a benthic fish aggregating device and contribute to the depletion of fish stocks particularly when the resources are over exploited.

In Oman the Government might consider pilot studies in a closed fishing area to assess the impact of artificial reefs on local lobsters. Similar approaches in Florida, Hawaii, South Africa and New Zealand have not only improved the stock densities but also resulted in larger size lobsters within the sanctuary/reserved areas (Chubb, 2000). In due course, the concept should be developed as a community – based project, as practiced in the Philippines (Miclat and Miclat, 1989). By doing so, the fishermen are made to realize that their direct involvement is important to rebuild lobster resources. In Philippines, fishermen are encouraged to participate in the construction, installation and monitoring of the artificial reefs. Miclats (1989) further reported that this approach develops a sense of responsibility to their own resources.

A detailed ecological study should be undertaken to determine the appropriate options depending on habitat conditions. Clearly, shelters scaled to the body size of the juvenile lobsters and ones that allow the social shift towards aggregation at juvenile sizes will successfully concentrate lobsters and improve their survival (Sosa-Cordero *et al,* 1998). The minimum management requirements would be a system that ensures the ownership of shelters, a sufficiently long closure period each year to allow the recovery of the population, the exit of adult lobsters to deeper habitats and the protection of identified pueruli settlement and juvenile habitats. Thus artificial reefs can be used positively by integrating with fisheries management strategies such as minimum size, closed season and area, limited entry, habitat protection and restoration (Balgos, 1995).

For effective stock enhancement, the government should also simultaneously work on lobster propagation followed by rearing of pueruli and juveniles for later sea ranching.

Together with artificial shelters at closed areas, sock enhancement may improve the stock levels in Omani waters.

7.3.2.10 Monitoring

Finally, there should be a clear system for monitoring the implementation and progress of the management plan, including what steps should be taken if the management plan is not achieving the set objectives. Only then will the management plan achieve its objectives.

APPENDIX - I

Lobster Traps used in Oman

Gravid Lobsters

Fishermen illegally removing eggs from gravid lobsters

Lobster Fishing Boat with Nets

Under sized lobster

APPENDIX – II

Appendix II

Oman – A brief profile

Oman, with some of the most biologically productive seas in the world, lies at the southern corner of the Arabian Peninsula between latitude 16° and 27° N. It is surrounded by three different water bodies: the Arabian Gulf through the Strait of Hormuz, the Gulf of Oman and the Arabian Sea. Each of these areas offers some unique characteristics. The Arabian Gulf is a shallow water mass with high salinity and temperature, whereas the Gulf of Oman ranges between 100 – 300 m depth while the Arabian Sea in the south east is the deepest of the three, with a maximum depth of 5000 meters (Randall, 1995).

Oman has a long coastline of about 3165-km with a Shelf area of about 58,000 km^2. The contribution by distance of different regions is shown in Table 1. Hydrologically, the Oman coastline is demarcated into 8 areas (Table 2). The detailed hydro-biological parameters of these areas are given in Table 3.

Table 1. Extent of Oman Coastline

Particulars	Distance (Km)
Coastline of Mainland	2111
Musandam Mainland	569
Masirah Mainland	188
Masirah Islands	45
Juzor Al Hallaniyat	90
Juzor Ad Damaniyat	20
Mahawt	10
Others	132
Total	**3165**

Table 2. Oman Coastline Distribution based on Hydrology

S.No	Distribution Pattern
1	Musandam Peninsula in the north and bisected by UAE
2	Shinas – Muscat
3	Muscat - Ras-al-Had
4	Ras-al-Had – Masirah
5	Masirah – Ras-al-Madrakah
6	Ras-al-Madrakah – Ra's Sharbithat
7	Ra's Sharbithat – Ra's Janjah
8	Ra's Janjah – Yemen Border

Source: Thangraja, 1995

Table 3. Hydro biological Parameters

Area		Temp(^{0}C)	pH	DO(ml/l)	Salinity(ppt)
1	Minimum	22.08	7.42	5.65	36.9
	Maximum	31.43	8.08	9.04	38.9
	Average	24.59	7.71	7.18	37.5
2		23.14	7.07	5.57	36.5
		31.74	7.97	10.19	38.9
		25.63	7.59	7.51	37
3		23.39	7.37	4.37	36.7
		29.36	8.86	8.59	37.5
		25.28	8.18	6.25	37.2
4		20.58	7.23	3.99	36
		26.77	8.9	8.08	37.7
		24.2	8.43	6.59	36.7
5		21.4	7.34	4.92	35.9
		26.6	8.88	9.13	37.7
		24.07	8.26	6.36	36.6
6		20.07	7.37	2.62	35.5
		26.18	8.74	6.86	37.1
		24.81	8.24	4.96	36.2
7		22.12	7.93	2.84	35.9
		25.38	8.43	6.71	36.7
		24.2	8.1	5.32	36.3
8		25.95	7.32	3.83	36.5
		27.59	7.96	6.58	37.1

Source: Thangaraja, 1995

Current Status of Fisheries in the Sultanate of Oman

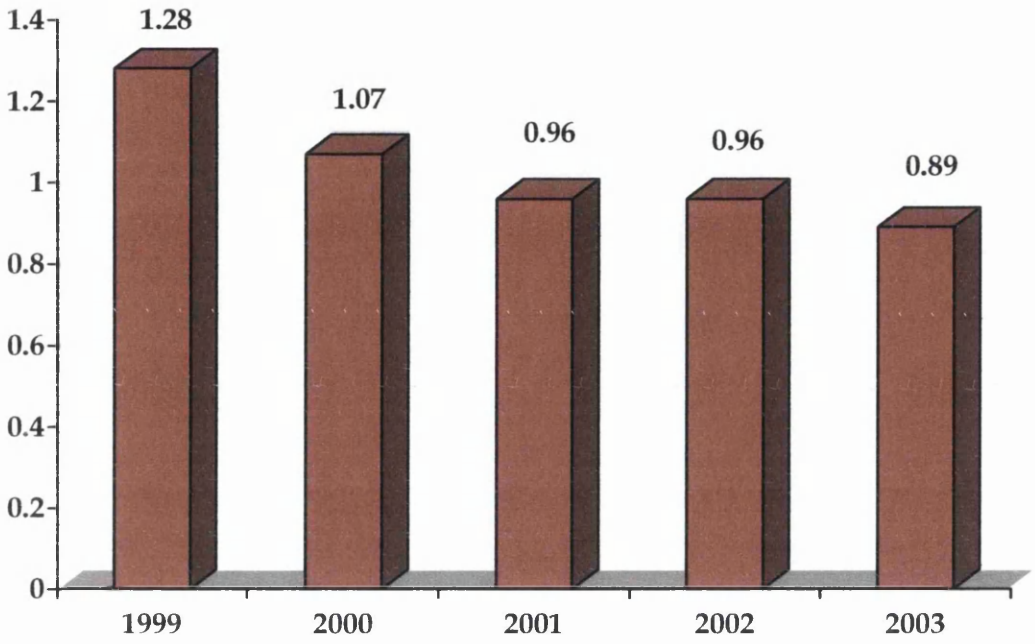
Agriculture and fishing have always been the principal contributors to the economy of the pre-oil Oman era. Historically fishing was second only to agriculture as an economic activity and the prime activity for those living in coastal areas. Both the Gulf of Oman and the Arabian Sea offer a variety of high value species, including abalone, kingfish, breams, tuna, grouper, shrimp and lobsters.

Even after the development of the oil industry, agriculture and fisheries continued to be one of the main sources of employment and income. Fisheries, once an activity embedded in Oman's seafaring tradition, is now a fairly developed industry as a result of the efforts of progressive regime. Fisheries sector is considered as an important source of non-oil income to the national economy (Al-Kharousi, 1999), as well as an example of the government's economic diversification drive.

In spite of all these developments and the government's commitment to improve the fishing industry, there remain many problems that require attention. The Sultanate's fishery authorities cannot afford to be complacent. Waste, misuse and over–exploitation of certain species by traditional and commercial fishing require statutory intervention to rectify the imbalance.

As in some developing nations, Oman's coastal fisheries are characterized by over exploitation. This vital sector of great socio-economic importance, employing about 30 to 35 thousand fishermen providing livelihood to more than 10% of the local population and being the largest non oil export earner of the country (RO 59 million in the year 2003) is on the decline in its contribution to the non-oil GDP (Fig. 1). Landings of high-value and popular species are in serious decline (Johnson and Al-Abdulsalaam, 1991).

Fig. 1 % Share of Fisheries Sector in Non Oil GDP



Source: Ministry of Economy, Sultanate of Oman

Reasons for the over – exploitation of many species include:

- Domestic population growth
- Rise in the international demand for fish
- Improvements in the internal market infrastructure
- Modern technologies
- Environmental conditions
- High price for certain species
- Poor fisheries management

If the Sultanate's fishery resources were managed in a scientific and responsible manner the sector could make a more sustainable contribution to Oman's economy. Moreover stocks of several economically important species require immediate action to arrest further decline.

APPENDIX – III

A. General Information

1. **Serial No.** _____
2. **Time: From**_____ **to** _____
3. **Town** _____ **Village** _____
4. **Date of Interview** _____

B. Fishing Assets

B1. Fishing vessel/s owned

Item	Vessel I	Vessel II	Vessel III
Length (ft)			
Year Acquired			
Cost of acquisition			
Method of acquisition 1.Own finance 2.Loan (source)			

B2.Engine

Item	Engine I	Engine II	Engine III
HP			
Year acquired			
Cost of acquisition			
Method of acquisition 1.Own finance 2.Loan (source)			

B3.Fishing Gears

Item	Gear I	Gear II	Gear III	Gear IV	Gear V
1.Type of gear					
2.No. of units					
3.Year Acquired					
4. Lobster species					
5.Depth (fm)					
6.Sale per trip					
7.Season					
8.Cost of acquisition					

B4. Method of Acquisition

Item	Gear I	Gear II	Gear III	Gear IV	Gear V
Own Finance					
Loan (Source)					

C. Fishing activities and fish marketing:

C5. Number of crew _____

C6. How many days per month do you fish on average? _____

C7. When do you normally not fish in a month Explain)_____

C8. And why? _____

C9. Where do you sell your catch? (State the auction name and commission charged)

_____

C10. How Much are your fuel and lubrication costs per trip? OR_____

C11. How Much are your other costs(food, ice, etc) per trip? OR_____

C12. How do you share the catch? Boat _____%, Crew_____%, Owner_____%

D. Fish resources current status

D13. Do you think the fishery of your community is declining?

Yes.....**1** Not Sure.....**2** No.....**3**

D14. How do you describe the problem of declining fishery here- No problem, Moderate, Severe or Extreme?

No Problem.....**1** Severe.....**3**

Moderate.....**2** Extreme.....**4**

D15. Have you noticed a decline in the quantity of lobsters in your catch compared with the past?

Yes.....**1** Not Sure.....**2** No.....**3**

D16 List those species _____

D17. What makes lobster resources decline? (Explain)

_____

_____

D18. As far as you know, do you think overfishing in this area could be stopped?

Yes.....1 Not Sure.....2 No.....3

D18.1. If "Yes", how should it be done?_____

D19. Have you personally done anything to get community to take action to reduce overfishing in this area?

Yes.....1 Not Sure.....2 No.....3

DI9.1. If "Yes", what have you done? _____

Instruction for section E, F and G:

The following statements are regarding your perception towards resources status, factors that may cause resource to decline, and the consequences of resource depletion. Please use the scales below to indicate to what extent you agree or disagree with the following statements. The choice is whether you (1) Disagree (D), (2) are Indifferent (I), or (3) Agree (A) with the statement.

E. Perception of resources status:

		A (3)	I (2)	D (1)
E20.	Your lobstercatch per trip declines	☐	☐	☐
E21.	The large lobsters are difficult to find or catch	☐	☐	☐
E22.	We need to spend longer hours looking for lobsters than we used to	☐	☐	☐
E23.	The percentage of trash fish in your daily catch has increased.	☐	☐	☐

F. Overfishing:

		A (3)	I (2)	D (1)
F24.	Lobsters resources decline if too many boats are operating in the same area	☐	☐	☐
F25.	Lobsters resources decline if all vessel are large in Size	☐	☐	☐
F26.	Lobsters resources decline if all vessels use high horse-powered engines	☐	☐	☐
F27.	Lobsters resources decline if all vessels employ a large number of nets/traps	☐	☐	☐
F28.	Lobsters resource decline if fishermen use Destructive gear	☐	☐	☐
F29.	Lobsters resources decline if fishermen increase their fishing time per trip	☐	☐	☐

G. The consequence of overfishing:

		A (3)	I (2)	D (1)
G30.	Your fishing area becomes further away from your village	☐	☐	☐
G31.	Your fishing hours become longer	☐	☐	☐
G32.	Your fuel consumption increases	☐	☐	☐
G33.	Many fishing areas are barren	☐	☐	☐
G34.	You have to use more fishing gears to catch lobsters	☐	☐	☐
G35.	Your income from fishing declines	☐	☐	☐

Instruction for section H:

The following statements are regarding your perception towards externalities. Please use the scale below to indicate to what extent you agree or disagree with the following statements. The choice is whether you (1) Disagree (D), (2) are Indifferent (I), or (3) Agree (A) with the statement.

H. Externalities in coastal fisheries		A (3)	I (2)	D (1)
H36.	You may face some difficulty in fishing if too many vessels operate in a small area	☐	☐	☐
H37.	Net/trap entanglement problems often occurs if too many vessels operate in the same area	☐	☐	☐
H38.	You cannot fish in the area where many colleagues are fishing	☐	☐	☐
H39.	Less catch is expected if you operate in the area which has just been fished by many colleagues	☐	☐	☐
H40.	Conflicts among fishermen at sea are rising	☐	☐	☐

I. Collective activities in fishing community:

I41. Is it necessary for all fishermen, including you, to work together to prevent resource depletion?

Yes.....1 Not Sure.....2 No.....3

I42. Do you go fishing in a group?

Yes.....1 Not Sure.....2 No.....3

I42.1. Why or why not? (explain) _____

I43. Do you always help your group members?

Yes.....1 Not Sure.....2 No.....3

I43.1. If I43 is yes, in what way? (Explain)_____

I44. Do you recognize all fishermen in your village?

Yes.....1 Not Sure.....2 No.....3

I45. Do you have any artificial reefs?

Yes.....1 Not Sure.....2 No.....3

I45.1. Why or why not? (Explain) _____

I45.2. Did some of your colleagues help you in the construction of the reefs?

Yes.....1 Not Sure.....2 No.....3

I46. What is the method you adopt to avoid the net entanglement problem?

_____

J. Factors that may influence collective activities:

1. Group size

J47. How many fishermen operate in the same fishing grounds where you operate?

_____People.

J48. Are they from your village?

Yes.....1 Not Sure.....2 No.....3

J49. Do you meet with them after the fishing trip?

Yes.....1 Not Sure.....2 No.....3

J49.1. If Yes, where do you meet? _____

J49.2. Why do you meet?_____

J49.3. How many of you meet regularly?_____

J50. Do you discuss fishing matters?

Yes.....1 Not Sure.....2 No.....3

2. Fishing technology constraints:

J51. How could you improve your catch rate?

Enlarge your vessel size.....1
Increase your engine horse-power.....2
Use a large number of nets/traps 3
Increase fishing time per trip.....4
Other (Explain)_____.....5

J52. Have you heard about the rule that bans the use of net in for lobster fishing?

Yes.....1 Not Sure.....2 No.....3

J53. Do you think this rule will improve lobster stock levels?

Yes.....1 Not Sure.....2 No.....3

J53.1. Why or why not? (Explain) _____

J54. Did all fishermen or some of them obey this rule in this village?

Yes.....1 Not Sure.....2 No.....3

J55. Are you willing to inform the authority about fishermen who violate this rule?

Yes.....1 Not Sure.....2 No.....3

J56. Are there fishermen use nets to catch lobsters in this village?

Yes.....1 Not Sure.....2 No.....3

J56.1. What are the consequences of this action?_____

J56.2. Are you against the use of this gear in your fishery?

Yes.....1 Not Sure.....2 No.....3

J56.3. Have you and your colleagues done anything to stop this?_____

3.Institutional factors:

J57. Do you agree that anybody who does not have a fishing licence should be banned from fishing?

Yes.....1 Not Sure.....2 No.....3

J58. Do you agree that breakers of fisheries laws should be penalized.

Yes.....1 Not Sure.....2 No.....3

J59. Do you think that the lobster resource will improve if current number of fishing vessels is reduced?

Yes.....1 Not Sure.....2 No.....3

J60. Have some of you united to resolve conflicts in fishing?

Yes.....1 Not Sure.....2 No.....3

J60.1. If "J60" is Yes: (a) Explain the conflicts _____

(b)How it was resolved _____

J61. Are there rules by which each one knows how he should fish?

Yes.....1 Not Sure.....2 No.....3

J62. If "J61" is Yes:

1)How you did learn of these? _____

2) Have anyone in your village been penalized because of rules breaking?

(Please explain) _____

J63. Do you think that fishermen from other villages are a threat to the fishery?

Yes.....1 Not Sure.....2 No.....3

J64. Do you agree that fishermen from other villages should not fish on your fishing ground?

(Explain)_____

J65. Do you think it will be possible for you and your colleagues to limit other Village's fishermen from fishing here?

Yes.....1 Not Sure.....2 No.....3

Instruction for section 4:

The following statements are concern your perception towards the benefits of collective conservation activities. Please use the scales below to indicate to what extent you agree or disagree with the following statements. The choice is whether you (1) Disagree (D), (2) are Indifferent (I), or (3) Agree (A) with the statement.

4. Benefits from Collective Conservation Activities	**A (3)**	**I (2)**	**D (1)**
J66. If resources are abundant, you do not require longer fishing hours to catch the same amount	☐	☐	☐
J67. If resources are abundant, you require less fuel to catch the same amount of fish	☐	☐	☐
J68. If resources are abundant, there will be less conflicts among fishermen at sea	☐	☐	☐
J69. Your fishing income will be higher if the lobsters resources improves	☐	☐	☐

5. Economic dependence on fishing

J70. Your age _____ years.

J71. How many people living together with you? _____

J72. How many years of school did you complete? _____years.

J73. How many people depend on your fishing activities?_____

J74. How many people in your house have a permanent job? _____

J75. The average monthly household expenditure: (OR)_____

J76. The average monthly household income

	Income (OR)	
	Fishing	Other Work
Respondent		
Other Person's kin relation		
One)		
Two)		
Three)		
Four)		
Total Income		

6. Social identity

J77. How many years have you been a fishermen?_____ years.

J78. Why do you fish? _____

J79. Are there others in your family who have a fisheries related job?

Yes ( )

Kin relation	Yes	No
Father	1	0
Sons	1	0
Brothers	1	0
Uncles	1	0
Cousins	1	0

Total score:_____

No ( )

J80. Do you have any other occupation beside fishing?

Work Time allocated

Fishing....._____

Farming....._____

Government or private sector....._____

Other_____....._____

J80.1. Why do you do this other work? _____

J81 (if doesn't have other work), Would it be easy for you to get another job?

Yes.....1 Not Sure.....2 No.....3

K. Attitude towards investment

K82. Are you considering another investment in fishing in the future?

	YES	NO
New boat	1	2
New motor	1	2
New gear	1	2

K83. If any item in K82 is "Yes" which of the followings will be your source of finance?

Own-saving.....1
Borrowed from commercial bank.....2
Both from own-saving and loan.....3
Government subsidies/low interest loans..... 4

L. Clubs

L84. What are the major problems of input and services procurement?

_____

L85. Are you in favor of developing fisheries cooperatives in your community to provide input and service supply.

Yes.....1 Not Sure.....2 No.....3

L86. Are you willing to join the cooperatives if you can get fishing gears and other fishing inputs at lower prices?

Yes.....1 Not Sure.....2 No.....3

L87. Do you agree that non-member should not sell their catch through the cooperative?

Yes.....1 Not Sure.....2 No.....3

M. Attitude towards the willingness to cooperate

Did you in the past year (Score one unit for each "yes")

	Item	Yes	No
M88	Returned under-sized lobsters into the sea when caught in your net/trap	1	0
M89	Set your nets/traps at a distance from other fishermen gears	1	0
M90	Inform on colleagues who break the fishing rules	1	0
M91	Attend workshops arranged by the Ministry of Agriculture and Fisheries	1	0
M92	Renew your fishing licence and boat licence	1	0
M93	Speak to the head of the tribe about the problem of your fishery	1	0
M94	Discuss fishing problems frequently with more than one fisherman	1	0
M95	Participate in a group to resolve conflicts in fishing	1	0
M96	Persuade others to follow fishing rules	1	0
M97	Visit the Governor office to complain about other fishermen activities in fishing	1	0
M98	Oppose catching lobsters with nets	1	0
M99	Own artificial reefs (number of reefs)	1	0

APPENDIX – IV A

Content Validity

Dear respondent

The following scales are used in the questionnaire, which will be administered to traditional fishermen in Southern Oman. The main objective of the questionnaire is to identify factors that influence collective choice in a lobster fishery.

I need your help to determine the **Content Validity** of the scales below. You are asked here to give your opinion regarding each item and the scale appropriateness and their relevance to the issue of the scale. Also you are asked to list any areas that are more relevant to the issue measured in the scale but not covered in the items.

Instruction for section A, B and C:

The following statements are concerning fishermen's perception towards **status of current lobster resources, fishermen's perception of overfishing and the consequence of overfishing.** Please use the scale below to rate each item for appropriateness and relevance to the issue measured by each scale. You can list issues that are pertinent to the issue of the scale but not covered in the items. **Please circle one number for each line.**

A. Status of current fish resources

Statement	EA	A	M	FA	NA
1. Your lobster catch per trip declines	5	4	3	2	1
2. Your target species per trip decline	5	4	3	2	1
3. The large lobsters are difficult to find or catch	5	4	3	2	1
4. You need to spend longer hours looking for lobsters than you used to.	5	4	3	2	1
5. The percentage of trash fish in your daily catch has increased.	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**

Comments: _____

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B. Overfishing:

Statement	EA	A	M	FA	NA
1. Lobster resources decline if too many vessels are operating in the same area	5	4	3	2	1
2. Lobster resources are limited due to small area	5	4	3	2	1
3. Lobster resources decline if all vessel are large in size	5	4	3	2	1
4. Lobster resources decline if all vessels use high horse-powered engines	5	4	3	2	1
5. Lobster resources decline if all vessels employ a large number of nets	5	4	3	2	1
6. Lobster resources decline if fishermen increase their fishing time per trip	5	4	3	2	1
7. Lobster resources decline if fishermen increase their fishing days per month	5	4	3	2	1
8. Lobster resources decline due to pollution	5	4	3	2	1
9. Lobster resources decline due to weather	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**

Comments: _____

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C. The consequence of overfishing

Statement	EA	A	M	FA	NA
1. Your catch contains a high proportion of trash fish	5	4	3	2	1
2. Your fishing area becomes further away from your village	5	4	3	2	1
3. Your fishing hours become longer	5	4	3	2	1
4. Your fuel consumption increases	5	4	3	2	1
5. Many fishing areas are barren	5	4	3	2	1
6. You have to use more fishing gears to catch fish	5	4	3	2	1
7. Your income declines	5	4	3	2	1
8. It is in God's hand how much fish remain in the sea	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**

Comments: _____

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D. Benefits from collective conservation activities

The following statements are concerning **benefits from collective conservation activities.** Please use the scale below to rate each item for appropriateness and relevance to the issue of the **benefits from collective conservation activities.** You can list issues that are pertinent to benefits from collective conservation activities but not covered in the items. Please circle one number for each line.

Statement	EA	A	M	FA	NA
1. You need not fish for long to catch a paying trip.	5	4	3	2	I
2. If lobster resources are abundant, you require less fuel to catch the same amount of fish	5	4	3	2	1
3. If lobster resources are abundant, there will be less conflicts among fishermen at sea	5	4	3	2	1
4. Your fishing income will be higher if the abundance of lobster resources increases	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**

Comments: _____

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E. Effects of (Negative) External forces in Coastal Fisheries

The following statements are concerning externalities in coastal fisheries. Please use the scale below to rate each item for appropriateness and relevance to the issue of externalities in coastal fisheries. Also you are asked to list issues that are pertinent to externalities in coastal fisheries but not covered in the items. Please circle one number for each line.

Statement	EA	A	M	FA	NA
1. You may face some difficulty in fishing if too many vessels operate in a small area	5	4	3	2	1
2. Net/trap entanglement problems often occur if too many vessels operate in the same area	5	4	3	2	1
3. You cannot fish in the area where a colleague is fishing	5	4	3	2	1
4. You cannot fish in the area where many colleagues are fishing	5	4	3	2	1
5. Less catch is expected if you operate in the area which has just been fished by many colleagues	5	4	3	2	1
6. Less catch is expected if you operate in the area which has just been fished by a colleague	5	4	3	2	1
7. Conflicts among fishermen at sea are rising	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**
Comments: _____

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Instruction for section F:

The following statements are measuring fishermen's willingness to cooperate to manage their lobster resources. Please use the scale below to indicate the appropriateness of the statements listed below. Also you are asked to list issues that are pertinent to cooperation but not covered in the items. Please circle one number for each line

G. Willingness to cooperate

Item	EA	A	M	FA	NA
1. You returned under-sized lobsters into the sea when caught in your net	5	4	3	2	1
2. Set your nets/traps at a distance from other fishermen gears	5	4	3	2	1
3. Inform on colleague who break the fishing rules	5	4	3	2	1
4. Attend workshops arranged by the Ministry of Agriculture and Fisheries	5	4	3	2	1
5. Renew your fishing licence and boat licence	5	4	3	2	1
6. Speak to the head of the tribe about the problem of your Fishery	5	4	3	2	1
7. Discuss fishing problems frequently with more than one fisherman	5	4	3	2	1
8. Participate in a group to resolve conflicts in fishing	5	4	3	2	1
9. Persuades others to follow fishing rules	5	4	3	2	1
10. Participated in reef construction in your village	5	4	3	2	1
II. Share important information	5	4	3	2	1
12. Share information about lobster concentration on the grounds	5	4	3	2	1
13. Tell your colleague about new technical developments	5	4	3	2	1
14. Share information about low cost sources of supply	5	4	3	2	1

(EA) Extremely Appropriate **(A) Appropriate** **(M) Moderate**
(FA) Fairly Appropriate **(NA) Not at all Appropriate**

Comments: _____

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Thank you for your cooperation

APPENDIX – IV B

Validity - Questionaire - Data Analysis

Points for the Answers	5	4	3	2	1			
A. Status of current lobster resources								
Statement	**EA**	**A**	**M**	**FA**	**NA**	**Total**		**Mean**
1. Your lobster catch per trip declines	8	3	1	0	0	55	4.58	4.58
2. Your lobster species per trip decline	5	6	1	0	0	52	4.33	4.33
3. The large lobster are difficult to find or catch	3	6	3	0	0	48	4.00	4.00
4. You need to spend longer hours looking for lobsters than you used to.	5	5	1	0	1	49	4.08	4.08
5. The percentage of trash fish in your daily catch has increased.	2	2	6	2	0	40	3.33	3.33
						48.8	4.07	
B. Overfishing:								
Statement	**EA**	**A**	**M**	**FA**	**NA**	**Total**		**Mean**
1. Lobster resources decline if too many vessels are operating in the same area	8	3	1	0	0	55	4.58	4.58
2. Lobster resources are limited due to small area	3	5	3	1	0	46	3.83	3.83
3. Lobster resources decline if all vessel are large in size	3	4	5	0	0	46	3.83	3.83
engines	3	4	3	2	0	44	3.67	3.67
5. Lobster resources decline if all vessels employ a large number of nets	8	2	2	0	0	54	4.50	4.50
6. Lobster resources decline if fishermen increase their fishing time per trip	4	7	1	0	0	51	4.25	4.25
7. Lobster resources decline if fishermen increase their fishing days per month	4	7	0	0	1	49	4.08	4.08
8. Lobster resources decline due to pollution	4	5	0	3	0	46	3.83	3.83
9. Lobster resources decline due to weather	2	3	4	2	1	39	3.25	3.25
						48	**3.98**	4.78

	C. The consequence of overfishing								
	Statement	**EA**	**A**	**M**	**FA**	**NA**			
	1. Your catch contains a high proportion of trash fish	1	3	7	0	1	39	3.25	3.25
	2. Your fishing area becomes further away from your village	5	5	2	0	0	51	4.25	4.25
	3. Your fishing hours become longer	4	8				52	4.33	4.33
	4. Your fuel consumption increases	4	8				52	4.33	4.33
	5. Many fishing areas are barren	9	2			1	54	4.50	4.50
	6. You have to use more fishing gears to catch lobster	6	5	1			53	4.42	4.42
	7. Your income declines	8	3	1			55	4.58	4.58
	8. It is in God's hand how much lobsters remain in the sea		1	1	1	9	18	1.50	1.50
							46.75	**3.90**	
	D. Benefits from collective conservation activities								
	Statement	**EA**	**A**	**M**	**FA**	**NA**			
	1. You need not fish for long to catch a paying trip.	2	5	2		3	39	3.25	3.25
	2. If lobster resources are abundant, you require less fuel to catch the same amount of fish	6	4	1		1	50	4.17	4.17
	3. If lobster resources are abundant, there will be less conflicts among fishermen at sea	4	4	3		1	46	3.83	3.83
	4. Your fishing income will be higher if the abundance of lobster resources increases	6	4	1		1	50	4.17	4.17
							46.25	**3.85**	
	E. Externalities in Coastal Fisheries								
	Statement	**EA**	**A**	**M**	**FA**	**NA**			
	I. You may face some difficulty in fishing if too many vessels operate in a small area	3	7	1		1	47	3.92	3.92
	2. Net/trap entanglement problems often occur if too many vessels operate in the same area	4	3	3		2	43	3.58	3.58
	3. You cannot fish in the area where a colleague is fishing	1	1	5	3	2	32	2.67	2.67
	4. You cannot fish in the area where many colleagues are fishing	1	3	4	2	2	35	2.92	2.92

	5. Less catch is expected if you operate in the area which has just been fished by many colleagues	1	6	3		2	40	3.33	3.33
	6. Less catch is expected if you operate in the area which has just been fished by a colleague	1	4	4	1	2	37	3.08	3.08
	7. Conflicts among fishermen at sea are rising	5	4	1		2	46	3.83	3.83
							40	**3.33**	
	F. Willingness to cooperate								
	Item	EA	A	M	FA	NA			
	I. You returned under-sized lobsters into the sea when caught in your net	10	2				58	4.83	4.83
	2. Set your nets/traps at a distance from other fishermen gears	7	4	1			54	4.50	4.50
	3. Inform on colleague who break the fishing rules	8	2			2	50	4.17	4.17
	Fisheries	9	2			1	54	4.50	4.50
	5. Renew your fishing licence and boat licence	9	1	1	1		54	4.50	4.50
	6. Speak to the head of the tribe about the problem of your Fishery	9	3				57	4.75	4.75
	7. Discuss fishing problems frequently with more than one fisherman	6	6				54	4.50	4.50
	8. Participate in a group to resolve conflicts in fishing	9	2			1	54	4.50	4.50
	9. Persuades others to follow fishing rules	10		1		1	54	4.50	4.50
	10. Participated in reef construction in your village	6	1	1	1	3	42	3.50	3.50
	11. Share important information	5	3	2		2	45	3.75	3.75
	12. Share information about lobster concentration on the grounds	5	2	3	1	1	45	3.75	3.75
	13. Tell your colleague about new technical developments	6	2	2	1	1	47	3.92	3.92
	14. Share information about low cost sources of supply	7	1	3		1	49	4.08	4.08
							51.214	**4.27**	

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