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A SURVEY OF THE LOBSTER FISHERY OF THE NORTH EASTERN REGION (PUNTLAND) BETWEEN FOAR AND EYL DURING NOVEMBER 1998

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EXECUTIVE SUMMARY

This report contains a scientific evaluation of the lobster fishery along the north-east (Puntland) coast of Somalia following a four week survey in the area. Because of the limited time frame for data collection and the logistical and political problems associated with working along the Somali coast, there are necessarily some limitations in the data. These have been discussed as objectively as possible. Appendix 1 contains the proceedings of the lobster fishery workshop which was held immediately after the end of the survey. It should be noted that some of the values quoted in the workshop report were based on a very rapid preliminary assessment of the data collected, and may thus be slightly different to values in the main report. Appendix 2 is a species list of fish observed by the survey team during the course of their work. Some of these are new distribution records for the species.

Artisanal fishing has a fairly long tradition among the people of Somalia, although historically fishing effort has been small and directed at shallow inshore species. After the drought of 1973-74 the government resettled large numbers of nomadic herdsmen along the coast and trained them as fishermen. More recently, a number of development projects, some of which have been funded by Non-Government Organisations, have increased the efficiency, scope and effort of fishing operations, to the point where some fish stocks now appear to be in danger of over-exploitation. The lobster (*Panulirus homarus)* resource that is distributed along the north-eastern inshore coastal area is typical of such a stock. Initially catches were very good and this resulted in escalating investment in the fishery, which in turn resulted in increased fishing effort. Eventually catches and catch rates started to decline and there is now serious concern that the resource may be over-fished. The decline in the lobster fishery has been of particular concern to Aid organisations attempting to improve the socio-economic conditions of the Somali people, because of the importance of the lobster fishery in the coastal economy.

Lobster fishing takes place mainly from October-November and February-April, because monsoon winds make the sea rough during the other months of the year. In the October-November season, lobsters are caught mainly by means of tangle nets although breathhold divers make a small contribution to the catches. During February, March and April, traps made of woven sticks are set to catch lobsters and tangle nets are hardly used. The reason advanced by fishermen for the change in gear type is that the lobsters do not feed in October/November, and thus do not enter traps, whereas in February-April, lobsters feed actively and are attracted to baited traps. Lobsters are processed at villages where there are freezer trucks. The presence of freezer trucks depends on road access to the coast, which is generally very poor. At processing stations, lobsters are tailed and individual lobsters are packed in small plastic packets for freezing. All lobsters, regardless of size or breeding condition, are retained by fishermen. The frozen lobster tails are all exported to Dubai. Lobster fishing takes place in extremely harsh conditions and fishermen and traders have to contend with great difficulties associated with the physical conditions on the coast, the climate, the lack of infrastructure and the lack of investment capital.

A survey of the lobster resource along the Puntland coast was commissioned by the IUCN Eastern African Regional Office, as part of the Somali Natural Resources Management Programme. The Oceanographic Research Institute, Durban, as a long-standing IUCN member, was contracted to carry out the survey between Foar and Eyl. The objectives were 1) to assess lobster densities in the main fishing areas, 2) to collect data on size composition, sex ratios and breeding condition of the commercial catch, 3) to collect information on effort, gear type and catch per unit effort (CPUE) in the fishery and 4) to present the collected information to participants in the fishing industry so that management scenarios could be developed and implemented.

The survey was intended to cover the area between Foar and Eyl. Hijacking and the theft of much of the diving and boating equipment resulted in the diving team being forced to operate between Dudura and Barmadobe, a distance of approximately 133km. Two divers searched an estimated 12 185 m^2 of reef. Lobster densities assessed by transect counts and free ranging timed searches were 4 lobsters per 100 m^2 of reef area. Diving conditions were extremely difficult throughout the survey and densities may have been under-estimated. During a 25 minute SCUBA dive, an average of 13 lobsters was seen. The total lobster stock between Foar and Eyl was estimated at 1 200 600 lobsters or 264 tonnes. However, the

estimate is very dependent on the assumptions made about the total inshore reef area along the east coast of Somalia
The average size of lobsters caught by the commercial fishery was 59mm carapace length (CL) for females and 62 mm CL for males. The size at which female lobsters became mature was calculated as 58 mm CL and the main breeding season appears to be in October/November. Although the tangle net fishery appears to catch fairly large lobsters, 52% of females caught were below the size at which they reach maturity. Sex ratios were generally biased in favour of males (1.3 males for every 1 female), although one sample from a northern fishing village contained three females for every male. Length/weight and carapace length/total length relationships calculated for *P. homarus* in Somalia were very similar to those in southern Africa.

A unit of fishing effort was difficult to define for a number of reasons. Average CPUE was 34 kg lobsters per boat per day, and 1.5 kg lobsters per man per day. There were an estimated 1 220 fishermen between Foar and Eyl and the estimated annual catch was in the region of 280 tonnes. Total stock size was probably somewhat under-estimated, since it is unlikely (but not impossible) that the total standing stock is caught every year. All the people interviewed as part of a survey of attitudes in the fishery said that catches had declined, and most felt that the reasons for the decline were the increasing fishing effort and the capture of lobsters by foreign trawlers. Most of the people interviewed felt that some form of fishery management was also needed.

Natural mortality of *P. homarus* was estimated as being between 0.60 and 0.85 (the death of between 45% and 57% of the population annually from natural causes). Catch curve estimates of total mortality were between 1.84 and 2.70, with 1.84 probably being the more realistic figure (the annual death of 84% of the population from fishing and natural causes together). In the short to medium term, the yield-per-recruit for both males and female lobsters would be between 30% and 55% higher if a minimum size limit of at least 60 mm CL was observed by the fishermen. The decline in lobster egg production to levels that might endanger the recruitment of young lobsters is much more rapid and occurs at much lower levels of fishing effort if small (40 mm CL) female lobsters are caught and retained, than if females are only caught when they have reached 60 mm CL. Current egg production may be only about 10% of the original egg production before the fishery started, and this could easily result in very few larval and juvenile lobsters surviving long enough to become part of the fishable stock (recruitment failure). A 60 mm CL size limit on the capture of female lobsters would greatly reduce the chances of recruitment failure which would lead to the collapse of the lobster stock.

Fishing pressure on the inshore Somali lobster stock is unlikely to decline in the short term. Almost the entire stock seems to be accessible to fishermen and there appear to be no unexploited areas. The lobster populations along the Yemen, Oman and Somali coasts probably all constitute a single stock and all of them are heavily fished. The heaviest fishing occurs during the main reproductive period and small or egg bearing lobsters are not returned alive to the water. It is suggested that the implementation of a minimum size limit of 60 mm CL and the return of egg bearing lobsters to the water would have considerable benefits for both the yield from the fishery and egg production.

During a two day workshop held at the end of the survey (see Appendix) a number of management options were agreed to by fishery participants. These included the implementation of a minimum size limit of 60 mm CL, the return of egg bearing lobsters to the water, the setting of a minimum mesh size of 100 mm stretched mesh for tangle nets, and the introduction of escape gaps in lobster traps. The results of the survey indicate that if these management measures are effectively implemented and enforced, the lobster fishery along the Puntland coast should be sustainable at the current levels of fishing effort. The traders that buy lobsters from the fishermen are seen as central to the implementation of any management measures.

INTRODUCTION

The Somali maritime zone is one of the largest in the western Indian Ocean and has one of the most important large marine ecosystems (the Somali Current Marine Ecosystem) in the Indian Ocean. A feature of this ecosystem is the seasonal upwelling and consequent high productivity resulting from the Somali current. The coastline is approximately 3300 km long and is divided into two major coastal areas. The north coast is bordered by the Gulf of Aden and is about 1300 km, while the 2000 km east coast forms the western edge of the Indian Ocean. The continental shelf is relatively narrow in most places and rarely exceeds 15 km in width although it extends to 80 km offshore in the north-east region around Haafun. Along the east coast the south-west monsoon occurs from May to August and the strong winds generate a fast flowing current which travels in a north-easterly direction during this period. As the surface current approaches the Horn of Africa, it deviates away from the coast and the water in the coastal zone is replaced by cold, nutrient rich, upwelled water, which results in high productivity in the area. During the north-east monsoon (December to February), current reversal takes place, but the south-westerly current is not as strong as the north-easterly current, and no upwelling takes place (Sommer et al. 1996; Baars et al. 1998). During the inter-monsoon periods (October-November and March-April), the winds are relatively light and the seas settled, and it is in these periods that most of the fishing activity along the east coast takes place.

Burbridge (1987), Stromme (1987) and Everett & Kelleher (1998) provide a limited description of the development of the Somali fisheries by the Italians in the 1930s, the Russians in the 1970s, and later through the Somali Marine Products project funded by the Federal Republic of Germany in the 1980s. Since the civil war, fisheries development has been funded mainly by foreign aid through Non-Government Organisations (NGOs). There is a lack of reliable information regarding the early years of all aspects of fishing in Somalia. Since the collapse of the government there has been no formal collection of fishery statistics of any kind.

Artisanal fishing apparently has a fairly long tradition along the Somalia coast and fishing communities are found scattered along the entire coast (Stromme 1987; Charters & Champagne 1997; Lovatelli 1995). A shark fin fishery appears to have been in operation for at least 30 years and shallow water lobsters have been caught probably for about 20 years. Historically the fishing efforts of the Somali people have been directed at shallow water inshore species despite the rich deeper water pelagic and demersal fish resources, which result from the high productivity in the upwelling region (Stromme 1987; Burbridge 1987; Baars et al. 1998). Offshore fishing was always conducted by foreign vessels under license to the Somali Government before the 1990 civil war and subsequently under no authority at all. After the drought of 1973-74, the government resettled large numbers of nomadic herdsmen along the coast and trained them as fishermen, in an effort to relieve the economic hardship caused by the drought-induced loss of livestock (Stromme 1987). The government organised fishing communities into cooperatives with common ownership of boats, fishing gear and processing facilities. Trade was then taken care of by the cooperative agencies. However, in the 1980s, individual fishermen became increasingly responsible for their own fishing gear and the cooperatives began to compete with private fish traders. Over the last decade there have also been a number of development projects funded largely by NGOs which have aimed to increase the efficiency of the local fishing industry. This has resulted in a significant increase in fishing effort of all types in coastal areas. With no current government fisheries policy in Somalia, all fisheries are open access, and, combined with the escalation in fishing effort, this appears to be leading to the serial depletion of numerous valuable marine stocks.

A variety of lobsters of the genus *Panulirus* are found along the entire coast of Somalia, as well as two species of deep water lobster (*Puerulus sewelli* and *Puerulus carinatus*), which are fished at depths of 150-400 m by trawlers. Various reports describe a deepwater crustacean fishery of 1000-2000 tonnes p.a. (Haakonsen 1983; Everett & Kelleher 1998), but there is no information on the species composition of this fishery, mainly because deep water trawling has always been carried out by foreign vessels which submit no catch and effort data. Along the east coast, the predominant lobster species is *Panulirus homarus megasculptus*, although very small numbers of other tropical lobster species such as *Panulirus ornatus* and *Panulirus longipes* also occur. Lobsters such as *P. ornatus*, *Panulirus versicolor* and *Panulirus penicillatus*, which are typical of a coral reef biotope, are probably found along the northern coast and *P.*

homarus is rare. The north coast species do not occur in sufficiently large numbers to warrant a dedicated fishery, but *P.homarus* stocks on the east coast of Somalia appear to have been exploited for a considerable time. This species is distributed throughout the north-western corner of the Indian Ocean and commercial lobster fisheries also occur in the Sultanate of Oman and in Yemen (George 1963; Sanders & Bouhlel 1984; Johnson & Al-Abdulsalaam 1991). Both these latter fisheries have declined because of over-exploitation (Johnson & Al-Abdulsalaam 1991). It seems anomalous that significant stocks of occur on the coast of Yemen, while 250 km across the Gulf of Aden, on the northern coast of Somalia, the species is not common. Presumably the physical and oceanographic conditions in the two areas are fairly similar and it is difficult to account for this distribution pattern.

Along the east coast of Somalia, the lobster fishery has become the single most important fishery in the last eight years (since 1990). The number of lobster fishermen has increased very rapidly, and there has been considerable investment by both traders, who buy lobsters from the fishermen, and fishermen themselves, in lobster fishing gear. This investment has taken the form of freezer trucks, boats, outboard engines, fuel, nets and traps. All of the catch is exported to Dubai in the form of tailed lobsters. Fishing originally took place only in October-November and February-April, when the monsoon winds are light and the seas relatively settled. This resulted in an effective seven month closed season. However, there is an increasing trend to fish for lobsters throughout the year, in an effort to increase returns on capital invested in the industry. This trend has accelerated in the last two or three years because of a decline in lobster catches and a consequent eagerness by investors to recoup their capital. Apart from the weather-induced closed fishing season, there are no constraints on the lobster fishery. There are no controls on the amount, size or reproductive condition of animals captured, nor are there any limits on the number of fishermen that can enter the fishery. All lobsters, regardless of size or breeding condition are kept, and no lobsters are returned to the water.

Lobsters are captured with a variety of fishing gear. In the October-November season, tangle nets laid across reef areas are almost exclusively used for lobster fishing and provide the bulk of the catch. Much of the lobster resource is located in shallow water less than five metres deep and fishermen also dive and spear lobsters. However, the inshore water clarity is very poor along much of the east coast during this period, and diver catches form a relatively small proportion of the commercial catch. Cast nets thrown over reef areas are also used by shore based fishermen to catch lobsters, but this appears to be an inefficient method of fishing at the current level of stocks. During the longer fishing season from February to April, dome shaped traps made of thin sticks are the principal fishing method and tangle nets are hardly used. Apparently the water clarity is better at this time of the year and diver catches may form a slightly larger proportion of the catch. Presumably cast nets are also used. Beehive traps made of galvanised wire and plastic are also found in some fishing areas, but they are a relatively recent introduction.

Data on the total annual lobster catch are poor and it is sometimes not clear whether the reported figures are for whole weight or tail weight. In 1985, 116 tonnes were apparently caught, while the 1994 and 1995 figures are 540 and 300 tonnes respectively (Everett & Kelleher 1998). Haakonsen (1983) proposed a potential catch of 500 tonnes of shallow water lobster for the east coast of Somalia. Diab & Helder (1995) reported the processing of 205 kg of whole lobster per day from a single fishing village (Benda Beyla). Assuming a five month season, this amounts to approximately 31 tonnes p.a. from this village. However, although there appear to be little reliable historical data, over the last two years, lobster catches have declined significantly. Lobster fishermen along the east coast all agree that there are not nearly as many lobsters as there used to be, and traders who buy lobsters from the fishermen state that their freezer trucks now make less than half the number of trips to the towns serviced by airstrips. Previously a trader with a freezer truck would collect lobsters until the truck was full and then drive to an export centre where the lobsters would be flown to Dubai. Over the past two years, catches appear to have declined so much that traders now combine their catches in a single truck for the journey to the major towns. Anecdotal information from traders indicates that the lobster resource is probably overfished. One trader (Eyl area) said that boat catches were currently 25-35 kg of lobsters per day, but had been in the region of 125 kg per day in the past and even as high as 250 kg of lobsters per day. A second trader at Kulule said that she would only send one truckload of lobsters to the airport in the current (1998) October-November fishing season, whereas in past years she would have sent four. Clearly, lobster catches have declined significantly in the last few years.

Reasons given by participants in the lobster fishery for the decline are varied. They all acknowledge a rapid increase in fishing effort and most of them believe that it would be beneficial not to catch small lobsters and egg bearing females. However, most fishermen are convinced that foreign trawlers are largely responsible for the decline in the inshore lobster fishery. They believe that trawlers come close inshore at night and trawl over lobster reefs, damaging the reef habitat and removing lobsters.

Fishing operations: Captured lobsters are transported in sacks to processing stations, which are located in the vicinity of freezer trucks. There is often more than one freezer truck located at a village or processing station, and generally each freezer truck is owned by a different trader. Lobsters are transported either on foot, or by boat. Some fishermen who do not own a boat and are fishing a considerable distance from the processing station, hand their catches to "collector" boats which carry their catches to the processing station. Boats are generally heavy 6.5 m GRP vessels made in Dubai and powered by a 15 hp outboard engine, although longer narrower 8.5 m wooden vessels are also used. A collector boat may service 50-60 fishermen scattered up to 10 km along the shore on either side of a fishing village. Sometimes lobsters remain out of the water for a considerable time before transport to a processing station. Because the climate is so hot, this results in a marked deterioration in the quality of the lobster that arrives for processing. On arrival at the processing station, the catch is weighed in a whole state and becomes the property of the trader. Fishermen are paid 16 000-20 000 Somali shillings (SS) per kilogram of whole lobster (+8 500 SS = 1 USD). The price appears to be fixed by the traders at the start of a fishing season, and is higher (20 000 SS) in the north at Bender Beyla than in the south (16 000 SS) at Eyl. The landed price of fresh lobsters is thus 1.9-2.4 USD per kg. Despite the obvious competition that must exist between traders for the fishermen's catch, there appears to be no variation in the price paid to fishermen in the different areas. Traders sometimes "bond" fishermen by supplying them with fishing gear on credit, in which case that particular fisherman must sell his catch to the trader. However, foreign trawlers with freezer capacity have been known to approach close to shore and fishermen have then sold their catches directly to these vessels at a much higher price (40 000 SS per kg or approximately 4.7 USD per kg). Traders receive 20-22 USD per kg for lobsters exported to Dubai.

Processing stations consist of a crude table generally located under some kind of shade, and a number of plastic crates and large plastic bowls. Each trader has his own processors. An incision is made around the anus of a lobster to loosen the gut and under the carapace to sever connective muscular tissue, and the head is then pulled off, bringing the intestine with it. The lobster tails are then placed in sea water, and the meat at the front of the tail and the pleopods of berried females are trimmed with scissors. The tails are then lightly scrubbed in seawater to remove any remaining gut contents, packed individually in small plastic bags and crated. Crates are stored in the freezer trucks to await export. The position of freezer trucks along the coast is governed by road access, which is generally very poor. In some cases, the trucks can approach only to the edge of a high plateau above a fishing village. Crates of tailed lobsters must then be transported on foot up a considerable escarpment in order to reach the freezer facilities.

The conduct of lobster fishing operations along the east coast of Somalia seems incredible to persons familiar with commercial fishing operations in industrialised countries. The fishermen have to contend with great difficulties associated with the physical nature of the coastline, the climate, the lack of infrastructure and the lack of investment capital. Some of the major difficulties are: Large heavy boats powered by small engines, which increases the time spent at sea and thus reduces the distances that can be covered; difficulties in launching and retrieving boats because of their great weight and underpowering; long stretches of coast which consist of cliffs that fall vertically into the sea (fishermen set nets at the base of these cliffs by jumping off the cliff, retrieving a net thrown to them by an accomplice, swimming the net into position and then swimming along the base of the cliff until a place is found to exit the sea); very poor visibility for diving; extreme temperatures all year round coupled with the desert conditions of the physical environment; extreme logistical difficulties in the supply of fuel and spare parts for mechanical or fishing gear. Fishermen live in villages that are scattered along the coast and their living conditions are extremely harsh. Some of the villages are permanent and consist of formal stone and concrete buildings e.g. Bender Beyla and Eyl. Other villages are temporary, consisting entirely of shacks made of branches and twigs, plastic sheeting and sacking and they are only inhabited in the two main lobster fishing seasons (e.g. Kulule, Dudura and Barmadobi). Living conditions in these temporary villages are very basic.

Since the lobster fishery on the eastern Somali coast plays such an important role in the economy of the region, the decline in the fishery in terms of total catch and catch per unit effort has been of particular concern to development organisations attempting to improve the socio-economic conditions in the country. The IUCN Eastern African Regional Office has been implementing the Somali Natural Resources Management Programme which aims to achieve this objective by enhancing the ecological sustainability of natural resource use. Areas of concern for the IUCN are woodfuel conservation, fishery management and monitoring, marine conservation and land use planning. The fisheries component of Programme involves training in fishery monitoring of demersal, shark and reef fish exploitation, the development of fishery and conservation policies for the north-eastern section of Somalia, technical support to both fishermen and administrators, data analysis and management recommendations for different sectors of the fishing industry, as well as a survey of the lobster resource and management recommendations for its sustainable use. The Oceanographic Research Institute (ORI) in Durban, South Africa was contracted by the IUCN to assist in a number of these fishery related functions, and the terms of reference in the contract stated that a lobster survey was to be carried out between Foar and Eyl on the north-east coast of Somalia in November 1998. The objectives of the survey were:

1) to assess lobster densities in the main fishing areas;
2) to collect data on size composition, sex ratio and breeding condition of the commercial catch;
3) to collect information on the effort, gear type and catch per unit effort in the fishery;
4) to present the collected information to participants in the fishing industry, so that some form of management that would stabilise catches might be instituted.

The survey was undertaken by two diver scientists from ORI and logistical support was provided by Ocean Training and Promotions (OTP), a Somalia based NGO located in Bosaso.

MATERIALS AND METHODS

Survey area

Originally, the survey was intended to cover the area between Benda Beyla and Eyl (Fig. 1). Because road access to much of the coast is extremely difficult, the intention was to work by boat from north to south, diving at selected sites along the way, and linking up with a shore based party at Kulule, Dudura and Eyl (Fig. 1). On reaching Dudura 50 km south of Benda Beyla, fishermen in the area indicated that they were not happy with the presence of a foreign diving team and the divers were forced to travel from Dudura to Eyl by road. At Eyl, local fishermen strongly disapproved of the SCUBA diving survey and bandits hijacked all the SCUBA gear, compressor and an outboard engine. The diving team then returned to Benda Beyla and worked by sea as far north as Barmadobe. Thus the survey eventually covered the area between Dudura and Barmadobe, a distance of approximately 133 km. Dive sites were selected on the basis of boat travelling time but sometimes the availability of subtidal reef or safety considerations governed the choice of dive sites. The diving was done from an open 6.5 m GRP boat powered by a 15 hp outboard engine which travelled at a maximum speed of 8-10 km.h-1. Altogether, 35 sites between Barmadobe and Dudura were dived to assess lobster densities (Fig. 1). Almost all these sites were close inshore in shallow water 2-6 m deep, because there appeared to be no local knowledge of deeper reefs. Extensive efforts were made to locate deeper reefs with an echo sounder, but with very limited success. In the area surveyed, the rock lobster resource appears to be mainly limited to reefs that occur at the base of the cliffs that characterise much of the eastern Somalia coastline. However, 3 dives were made on reefs at depths of 8-14 m.

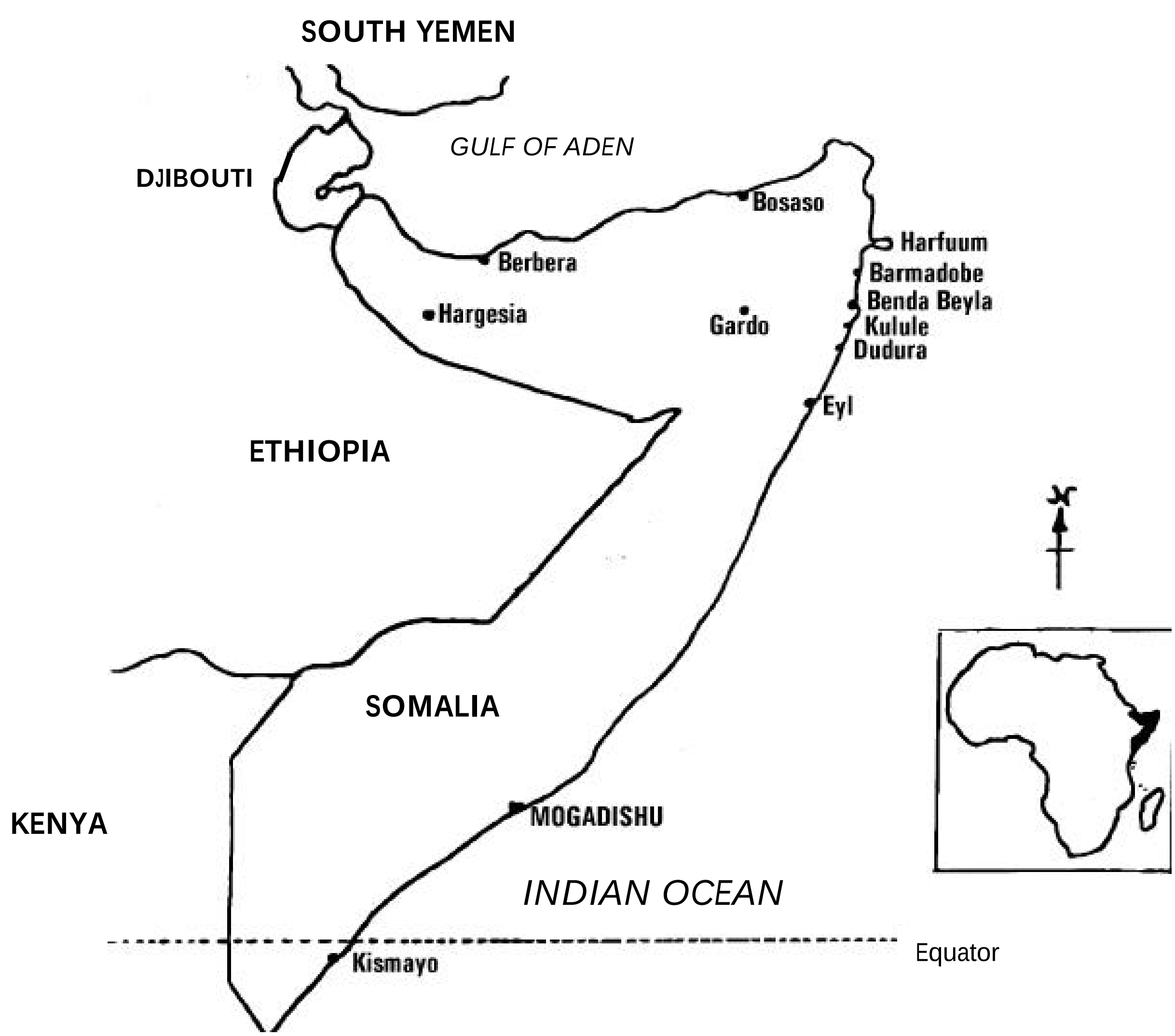


Fig. 1. The Somalia coastal zone showing the areas in which the lobster survey was conducted

Lobster densities

Considerable difficulties were encountered in the survey of lobster densities because of very poor underwater visibility, strong wave surge in the very shallow (2-6m) working area, the ubiquitous use of tangle nets on almost every available reef, and the theft of all SCUBA gear halfway through the survey.

Initially, lobster densities were assessed by transect counts on randomly selected reefs. It should be noted however, that although the general location of a dive site was randomly selected, sea and diving conditions to some extent governed where transects could be laid. Once a reef area had been located a 20m weighted transect line was laid across the reef and the number of lobsters within 1m on either side of the line were counted by a diver using SCUBA. Four or five transects were completed at each dive site and the time taken to swim each transect was recorded. Because of the difficult working conditions, the 20 m weighted rope transect line was later exchanged for a 10m light chain and 6-10 transects were counted and timed at each dive site. A second diver conducted a free ranging 25 minute search for lobsters, capturing animals that were accessible and counting all those that could not be captured. After the SCUBA gear and transect lines were stolen, lobster densities were assessed by 30 minute snorkel (breathhold) diving searches. The area searched was estimated from the area searched per unit time calculated from the initial timed transect swims. The actual bottom time of each diver during a 30 minute snorkel dive was measured by stopwatch and the assumption was made that a diver searched an equivalent area when he was on the bottom, regardless of whether he was breathhold diving or using SCUBA.

Size composition.

The size composition of the commercial catch was obtained at lobster processing stations along the coast. Much of the size frequency data were collected at Benda Beyla, because most time was spent there, but where possible other fishing villages were sampled. At least 100 animals from a daily catch were sampled each time, unless the total catch was less than 100 animals, in which case the entire catch was examined. Generally the whole animal was available, and data on size (carapace length to the nearest mm), sex, shell condition and the presence of berry, ovigerous setae and spermatophore were collected. At stations where processing had finished, only the heads from the daily catch were available and the presence of eggs and ovigerous setae could not be assessed. The data from heads only were omitted when size at maturity was estimated.

Fishing effort and CPUE

At each village, fishermen returning from the lobster grounds were interviewed to ascertain the size and power of the boat, the number of crew on the boat, the fishing gear used, the depth at which fishing took place, and the weight of lobsters caught per fishing trip. Collector boats were asked how many shore fishermen they collected from. It is not possible to assess daily catches per unit gear, because nets are often left in place overnight and sometimes for several days at a time, before being moved. A register of all the boats in the village (shark, lobster and line fishing) was also compiled. During two boat trips north and south of Benda Beyla, numbers of individuals engaged in lobster fishing activities were counted to determine the number of fishermen per km of coastline. A questionnaire survey of 60 people involved in the lobster fishery (traders, boat owners and fishermen) was also conducted to determine current perceptions of the state of the lobster resource.

Size at maturity

The presence of berry and spermatophoric masses on females was recorded during the collection of size composition data. The number of females in each size class that carried berry or a spermatophoric mass was expressed as a percentage of the total number of females in the size class. Size at 50% maturity was estimated by fitting a logistic equation (Butterworth et al. 1989) to the data for female reproductive state: The equation was

$$Sa = 1/[1 + e-(a-ar)/delta]$$

(where ar is the size corresponding to 50% maturity;
delta is the width of the maturity ogive which changes from values near 0 to values near 1;
a = the midpoint of the size class interval).

An optimizer routine that minimised the sum of squares was used to calculate the values of *delta* and *ar*. Since the percentage of berried or spermatophoric animals often does not reach 100%, the size at 50% maturity was defined as the size at which 50% of the asymptote was reached.

Morphometric data

Basic morphometric data were collected from lobsters captured during the density survey as well as animals obtained from the commercial catch. Carapace length and total length to the nearest mm were measured, as well as the width of the second abdominal segment along the dorsal midline and between the pleural spurs. Animals were weighed to the nearest 10 g on a conventional kitchen scale. Lack of facilities precluded more accurate weight measurements. Missing appendages and the presence of berry were noted, but because the number of animals available for morphometric measurement was severely limited, all data were used in calculations of morphometric relationships.

Yield- and egg-per-recruit models

There are no catch per unit effort (CPUE) data for rock lobster exploitation in Somalia, so it was not possible to develop production models of the stock. An age structured yield- and egg-per-recruit spreadsheet model was developed with the assumptions that all growth, natural mortality and fishing mortality take place instantaneously in the middle of the year. The size at which lobsters recruited to the fishery (i.e. the size at which they are first captured) was varied between 40 and 60 mm CL for females and 40 and 70mm CL for males. Total mortality was estimated from a length converted catch curve of the commercial catch composition data, using the FAO-ICLARM stock assessment software FISAT (Gayanilo, Sparre & Pauly 1996). Values for growth rate coefficients *K* and *Linf* were obtained from Sanders & Bouhlel (1984), who assessed the *P. homarus* stock in the coastal waters of the nearby People's Democratic Republic of Yemen. Values of natural mortality (M) were obtained from Fielding (1997; M = 0.6) and Sanders & Bouhlel (1984; M = 0.85). The size at 50% maturity and length/weight relationships were obtained from the values estimated from the commercial catch of Somalia (see above). Fecundity data for *P. homarus* were obtained from Berry (1971b). Male and female rock lobster populations were modelled separately because of different growth rates and length/weight relationships.

RESULTS

Lobster densities

Lobster densities were assessed at 35 dive sites between Dudura and Barmadobe. Based on the time taken to swim a 10 or 20m transect line and searching 1m either side of the line, divers searched 10.43m^2 of reef per minute (SE = 0.31) using SCUBA. Snorkel (breathhold) dives lasted 30 minutes. and, at depths of 4-6m, one diver spent 8.5 minutes of this as bottom time and the other diver had a bottom time of 10.26 minutes. Altogether an estimated 12 185m^2 of reef was covered during the lobster survey.

Estimates of rock lobster densities from 97 transects and 52 free ranging timed searches were combined. Mean density was 4.002 rock lobsters. 100 m-2 of reef (SE = 0.414) and 561 lobsters were counted. Transect counts of zero were recorded on many reefs and free ranging SCUBA diver lobster sightings during a 25 minute dive were low (13.42 lobsters.25 min-1 SE = 3.16; Range 0-71 lobsters). These figures for lobster densities are probably slight underestimates, because of the generally poor underwater visibility and the impossibility of diving in some of the deep caves encountered. Highest densities were 17 lobsters.100 m-2 of reef 15km south of Barmadobe and 13 lobsters.100 m-2 of reef at a point midway between Kulule and Dudura. It is probably significant that these two areas are at least 10 km from any fishing village and equidistant from villages on either side. Apart from two areas, north of Barmadobe (12-13m depth) and 15km north of Bender Beyla (+8m depth), no offshore reef was found and all the diving took place in shallow water close to the cliffs that are a feature of much of the coastline in the survey area. Lobster densities in these deeper areas were very similar to those of the shallower areas and there appears to be no deep water refuge for lobsters.

The total lobster stock in the area between Foar and Eyl was calculated on the assumption that there was an unbroken band of reef 100m wide between these two points (300km apart), and lobsters occurred at a density of 4.002 lobsters.100 m-2 of reef. Total stock size was thus 1 200 600 lobsters. Assuming a mean size of 60mm CL (see below) and a weight of 220g for a lobster of this size, there are 264 tonnes of lobsters in the area.

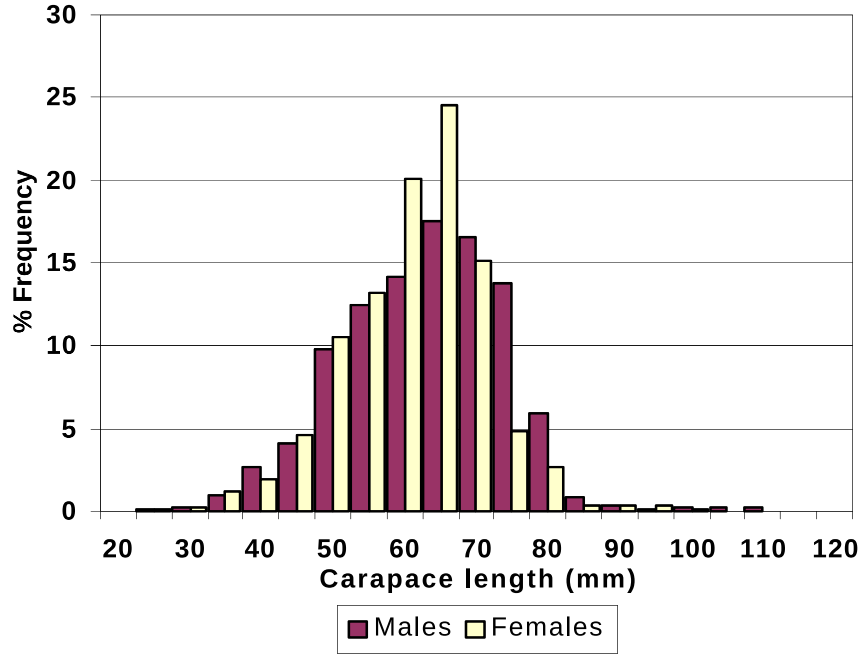


Fig. 2. Size frequency distribution of the commercial catch of P. homarus along the Puntaland coast

Catch size composition

The modal size class for rock lobsters captured by the commercial fishery was 60-65mm CL for both males (n = 1371) and females (n = 1036; Fig. 2). Most of these data were collected at Benda Beyla. Mean sizes of animals from commercial catches at individual fishing villages ranged from 57.7 – 62.1mm CL for females and 61.6 – 66.6 for males (Table 1). The overall sex ratio was 1:1.3 in favour of males and there were significantly more males at every fishing village (X2 test $P < 0.05$) except Barmadobi, where the sex ratio was 3:1in favour of females (Table 1). This female dominated sample was a single day's catch and it is possible that females aggregate at times. The smallest male and female lobsters measured were 25mm CL and 23mm CL respectively and the largest were animals of 110mm CL (male) and 98mm CL (female). Approximately 50% of the catch of both males and females was > 60mm CL, while animals larger than 55mm CL made up 70% of the catch. Only 24% of the catch of females and 38% of the catch of males was 65mm CL.

Table 1. Mean size of lobsters measured from the commercial catch of P. homarus at fishing villages along the Puntland coast of Somalia. The smallest and largest lobsters of each sex in each sample are also given.

Bur Bur

	Mean CL(mm)	SD	N
Females	62.12	9.60	130
Males	65.38	10.93	181
Sex ratio F:M 1:1.4			
Smallest female	23 mm CL		
Smallest male	25 mm CL		
Largest female	90 mm CL		
Largest male	105 mm CL		

Dudura

	Mean CL(mm)	SD	N
Females	57.71	2.47	40
Males	66.55	8.16	79
Sex ratio F:M 1:2			
Smallest female	41 mm CL		
Smallest male	43 mm CL		
Largest female	80 mm CL		
Largest male	110 mm CL		

Barmadobe

	Mean CL(mm)	SD	N
Females	60.25	9.80	63
Males	65.66	10.13	21
Sex ratio F:M 3:1			
Smallest female	44 mm CL		
Smallest male	47 mm CL		
Largest female	82 mm CL		
Largest male	107 mm CL		

Benda Beyla

	Mean CL(mm)	SD	N
Females	59.52	10.64	821
Males	60.47	11.15	1087
Sex ratio F:M 1:1.3			
Smallest female	29 mm CL		
Smallest male	28 mm CL		
Largest female	82 mm CL		
Largest male	107 mm CL		

All sites combined

	Mean CL(mm)	SD	N
Females	59.42	9.67	1036
Males	61.59	11.34	1371
Sex ratio F:M 1:1.3			
Smallest female	23 mm CL		
Smallest male	25 mm CL		
Largest female	98 mm CL		
Largest male	110 mm CL		

Catch and effort

A total of 71 boat skippers were interviewed (46 at Benda Beyla and 25 at Barmadobe). The boats used in the lobster fishery varied in length from 6 to 8.5 m and most were driven by 15 to 30 hp outboard motors and were crewed by an average of 5-6 crew. Gears used were gill-nets, cast-nets and diving with hand-held spears. The CPUE ranged from 0 - 200kg lobsters/boat/day with an average of 34kg lobsters/boat/day. However, because some boats also collected lobsters from fishermen along the shore it was useful to look at catch per man per day. A total of 213 boat fishermen and 317 shore fishermen caught 824kg of lobster. This gave an average CPUE of 1.5kg lobster/man/day, with each man generally using two nets.

During the lobster survey, counts were made of the total number of fishermen and boats seen fishing along the coast between Barmadobe and Dudura. From these counts it was estimated that there were approximately 4.1 fishermen per kilometre of coast (including boat fishermen, shore fishermen and divers). Assuming the same fishing effort occurs along the entire coast from Foar to Eyl (300km), there are approximately 1 220 fishermen operating along this stretch of coast. If lobster fishermen fish for approximately 150 days per year (Oct, Nov, Feb, Mar, Apr) at the current CPUE of 1.5kg lobster/man/day, the total annual catch is in the region of 280 tonnes (whole weight).

Interviews with the fishing community

A total of 60 people were interviewed at Bender Beyla and Kulule including 5 elders, 13 traders, 14 boat skippers and 28 fishermen. On average these people had been involved in the lobster fishery for about 12 years. All the people interviewed said that the lobster catches had declined (by an average of 73%) and the main reasons for this decline were: increasing effort (38%), trawling by foreign vessels (22%), fishing continuously throughout the year (20%), catching of juvenile lobster and females in berry (9%) and various other reasons (11%). All the people interviewed agreed that there had been a big increase in fishing effort and 91% believed that some form of management control was necessary. 77% of interviewees felt that no juvenile (immature) lobsters should be caught and 86% felt that lobsters in berry should not be kept and sold. When asked if they would be prepared to return juvenile lobsters or lobsters in berry alive back to the water, 87% said they would. Interviewees were asked whether they thought that lobster fishing should be allowed to take place throughout the year and 46% felt that there should be some form of closed season. If there was a closed season implemented, 97% said that they would be able to fish for other resources or find other sources of income. Examples of other resources, or activities they could engage in if not fishing for lobster included: shark fishing (76%), herding livestock (12%), fishing for finfish (10%) and various other trades (2%). Finally none of the respondents interviewed knew of any areas along the coast that were not fished for lobster (i.e. there are no *de facto* marine reserves).

Size at maturity

When calculating the size at maturity, it was assumed that female lobsters that have mated and carry a spermatophore or the remnants of one, or are carrying eggs on the *ovigerous setae* (berried) are mature. The size at which 50% of the female population reaches sexual maturity was 58 mm CL, while 25% of animals in the 50-55 mm CL size class and 10% of the animals in the 45-50 mm CL size class were mature. The smallest berried female was 45 mm CL and the smallest female carrying a spermatophore was 42 mm CL. During the October/November fishing season, 40% of female lobsters with a CL greater than or equal to the size at maturity were actually carrying eggs, while almost 60% were either berried or carried the remains of a spermatophore. It is thus likely that October/November is the main breeding season.

Morphometric relationships

Morphometric relationships were calculated for a carapace length range of 24 mm to 110 mm. Females were slightly heavier (total weight) than males of an equivalent carapace length, with the differences increasing as the animals increase in size. At the mean size (60 mm CL) at which animals are captured in the fishery, females are approximately 10% heavier than males. For a given carapace length, females are also slightly longer (total length) than males and have a wider second abdominal segment.

Table 2. Morphometric relationships for P. homarus along the Puntland coast of Somalia.

Relationship	***Sex***	***Regression***	N	***R2***
Carapace length (mm) Whole weight (g)	Females Males	$Wt_{(g)} = 0.0014CL_{(mm)}^{2.9388}$ $Wt_{(g)} = 0.0022CL_{(mm}^{2.8031}$	129 142	0.984 0.984
Total length (mm) Whole weight (g)	Females Males	$Wt_{(g)} = 0.0001TL_{(mm)}^{2.7863}$ $Wt_{(g)} = 0.0007TL_{(mm)}^{2.8999}$	129 142	0.979 0.975
Tail length (mm) Carapace length (mm)	Females Males	$TL_{(mm)} = 2.1391CL_{(mm)} – 7.0312$ $TL_{(mm)} = 1.6822CL_{(mm)} + 12.572$	146 156	0.968 0.935
Total length (mm) Carapace length (mm)	Females Males	$TL_{(mm)} = 3.1391CL_{(mm)} – 7.0312$ $TL_{(mm)} = 2.6822CL_{(mm)} + 12.572$	146 156	0.985 0.973
Carapace length (mm) Dorsal width of 2nd abdominal segment	Females Males	$W_{(mm)} = 0.8635CL_{(mm)} – 4.5989$ $W_{(mm)} = 0.6614CL_{(mm)} + 2.7882$	146 154	0.984 0.978
Carapace length (mm) Distance between spurs of 2nd abdominal segment	Females Males	$W_{(mm)} = 0.3751CL_{(mm} – 0.3084$ $W_{(mm)} = 0.3143CL_{(mm)} + 2.2644$	146 154	0.970 0.946

Mortality

Natural mortality for *P. homarus* along the east coast of South Africa was estimated as M = 0.6 by Fielding (1997), while Sanders & Bouhlel (1984) estimated M = 0.63-1.44 for lobsters in Yemen. Values of M = 0.6 and M = 0.85 were used in the yield- and egg-per-recruit model. Total mortality, calculated from a length converted catch curve of the size frequency data collected from the Somalia commercial fishery, K = 0.45 and L(= 110 mm CL for females and 127 mm CL for males, was Z = 1.84 (95% CI=1.28-2.40) for females and Z = 2.70 (95% CI=1.54-3.85) for males. Lower values of K and L(that apply to South African stocks of *P. homarus* gave slightly lower values of Z that ranged between 1.2 and 2.02. Since Z = F+ M, fishing mortality in the Somalia lobster fishery is likely to be in the range F = 1.0-2.1.

Yield- and egg-per-recruit

Biological parameters used in yield- and egg-per-recruit modelling are given in Table 3.The yield-per-recruit that can be expected from the Somalia rock lobster fishery was approximately 6% higher for males than for females. This is a result of the slightly faster growth rates estimated by Sanders & Bouhlel (1984) for males than females.

Table 3. Biological parameters used in yield and egg-per-recruit modelling of Somalia rock lobster (P. homarus) stocks along the Puntland coast.. CL = carapace length.

Parameter	Equation / value	
	Females	Males
Growth equation – CL (mm) at age t (years)	$110 (1-e^{-0.443(t-0.534)})$	$127 (1-e^{-0.455(t-0.610)})$
Weight (g) at size (CL in mm)	$0.0014 \times CL^{2.9388}$	$0.0022 \times CL^{2.8031}$
Age/size at 50% maturity	2.2 years / 58 mm CL	1.95 years / 58 mm CL
Age/size at 50% maturity + 1 year	3.2 years / 76 mm CL	2.95 years / 83 mm CL
Age/size at first capture	1.55 years / 40 mm CL	1.44 years / 40 mm CL
Fecundity (no. eggs produced)	11905 x CL – 523443	-

The absolute value of the yield-per-recruit is greatly affected by the rate of natural mortality. When M=0.6 the Y/R for both males and females is almost twice that when M = 0.85, regardless of the size at which the lobsters are first caught (Fig. 3a, b; Fig. 4a, b). However, at this stage, the absolute values are not really important since the estimate of M is uncertain. What is of far more relevance is that the Y/R would be very much greater if a minimum size limit was imposed on the fishery. Regardless of the value of M, Y/R for both males and females is considerably higher if male lobsters were only captured when they reached 70 mm CL and females when they reached 60 mm CL (Fig. 3b, 4b), instead of being captured once they reach 40 mm CL (Fig. 3a, 4a). If M = 0.85, then Y/R for both sexes would be 31% higher at F = 0.9 and approximately 60% higher at F = 1.5 . The increase in Y/R would be even more marked if M = 0.6, in which case Y/R would be 54% higher at F = 0.9 and 90% higher at F = 1.5.

The absolute value of the number of eggs produced is also greatly affected by the estimate of natural mortality. Intuitively, if fewer lobsters die from natural causes many more eggs will be produced (Fig. 5a b). As fishing pressure increases, the number of eggs produced declines rapidly. Clearly, the decline in egg production with fishing is very much more rapid when female lobsters are caught at 40 mm CL (Fig. 5a) rather than being left until they reach 60 mm CL, which is the size at maturity (Fig. 5b). Regardless of the value of M, egg production was reduced to 50% of its unharvested value (F50% EP) at approximately F = 0.3 when there was effectively no size limit on the female lobsters caught (lobsters caught at 40 mm CL). Egg production was reduced to 20% (F20%) of the unexploited value when F = 0.65 - 0.75, and to 10% (F10%) of the unexploited value at F = 1.15 -1.25 under conditions of no limitation on the size of females captured (Table 4). Based on a length converted catch curve of the commercial fishery, values of fishing mortality are likely to be at least F = 1.0 (see above), which implies that current egg production may only be about 10% of the egg production before the fishery started.

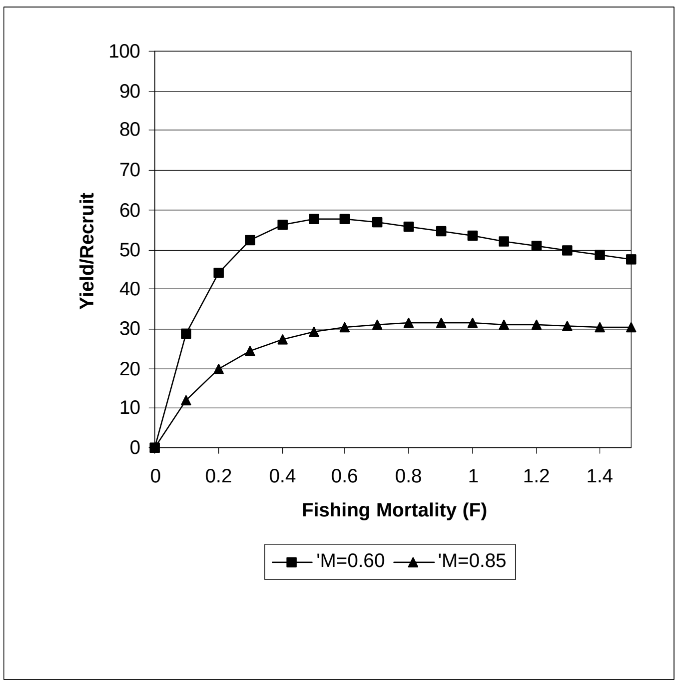
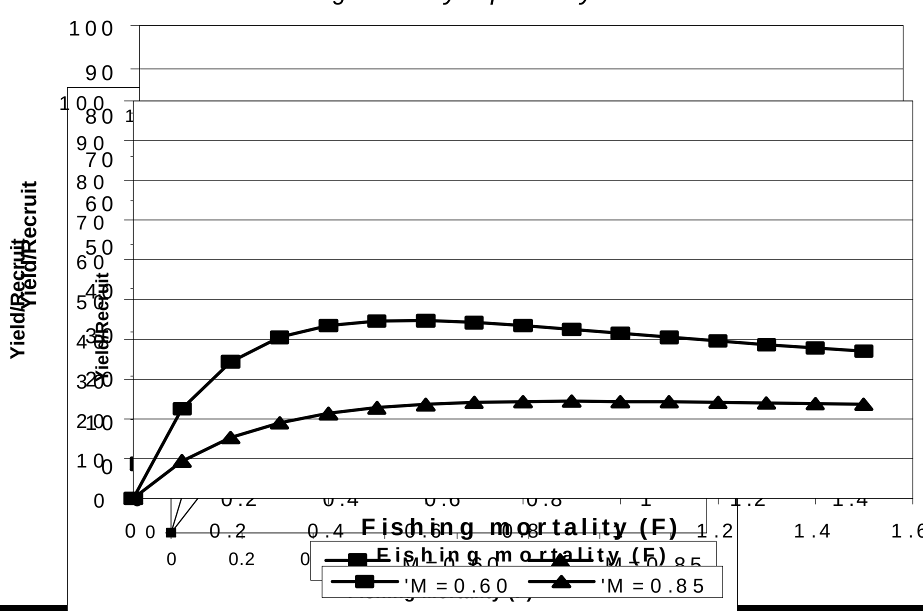


Fig. 3. Yield-per-recruit for male lobsters captured (a) when they attain 40 mm CL and (b) only once they have attained 70 mm CL. Current fishing mortality is probably F = 1.0-1.5.



When a 60 mm size limit on the capture of female lobsters is introduced, much higher fishing effort is required to reduce egg production to unacceptably low levels that might endanger recruitment. F50% only occurs at F=0.45-0.65, F20% occurs at F=1.6-2.0 and F10% is not reached within reasonable levels of fishing mortality (Table 5).

Fig. 4. Yield-per-recruit for female lobsters captured (a) when they attain 40 mm CL and (b) only once they have attained 60 mm CL. Current fishing mortality is probably F=1.0-1.5

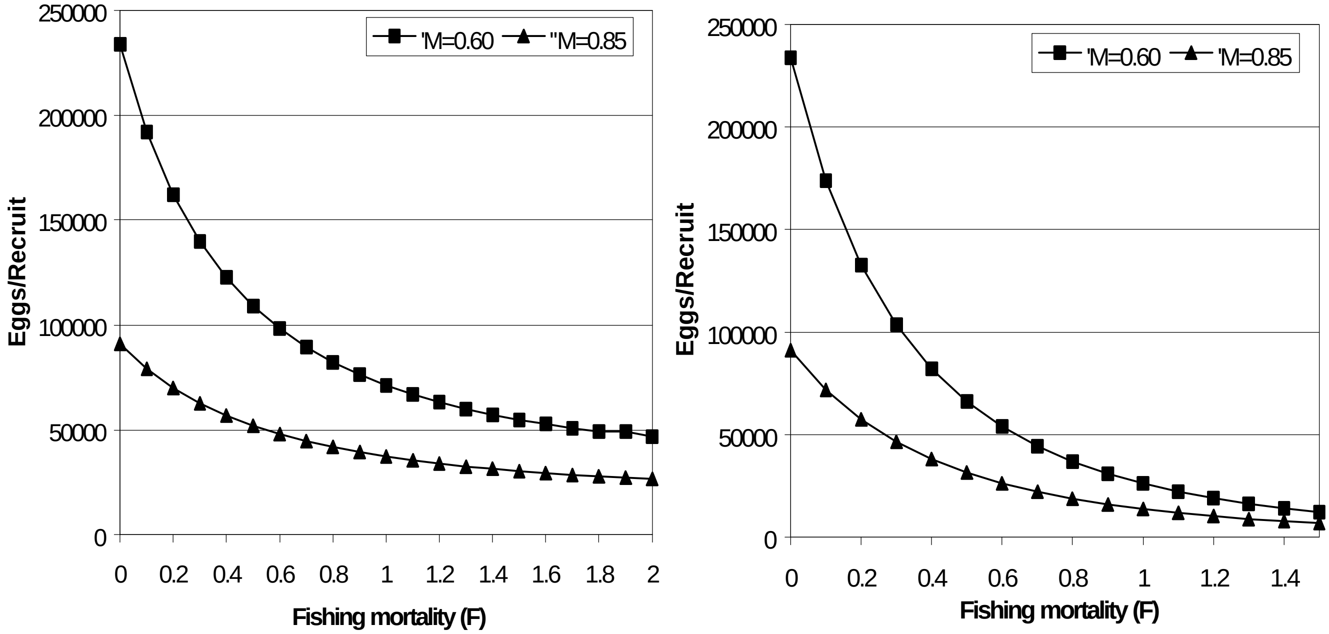


Fig. 5. Eggs-per-recruit for female lobsters (a) when they are captured once they attain 40 mm CL and (b) if they are only captured once they attain 60 mm CL. Current fishing mortality is probably F=1.0-1.5.

Table 4. Fishing effort at which the egg production is reduced to 50%, 20% and 10% of unexploited levels, for female *P. homarus* on the Puntland coast of Somalia, when there is no size limit on the capture of lobsters. Values are given for two levels of natural mortality.

M	$F_{50\%}$	$F_{20\%}$	$F_{10\%}$
0.60	0.25	0.65	1.15
0.85	0.30	0.75	1.25

Table 5. Fishing effort at which the egg production is reduced to 50%, 20% and 10% of unexploited levels, for female *P. homarus* on the Puntland coast of Somalia, when female lobsters are only captured once they have reached 60 mm CL. Values are given for two levels of natural mortality.

M	$F_{50\%}$	$F_{20\%}$	$F_{10\%}$
0.60	0.45	1.60	> 2.00
0.85	0.65	> 2.00	> 2.00

DISCUSSION

Lobster densities

Lobster densities determined during the survey were very low compared with similar surveys of the same species in southern Africa. In Somalia densities were 4 lobsters.100m-2 of reef compared with 7-12 lobsters.100 m-2 of reef in KwaZulu-Natal and 12-18 lobsters.100 m-2 in Transkei (Fielding et. al 1994; Fielding 1997). The difficult diving conditions may well have resulted in a slight underestimate of lobster densities, but lobster stocks along the Puntland coast of Somalia nevertheless appear to be considerably depressed because of the high exploitation rates. The type of reef habitat available to lobsters can clearly affect density, but the survey divers were experienced in this kind of work and most of the reef habitat dived appeared very suitable for *P. homarus*. It is also significant that the two areas encountered that were apparently too far from fishing villages to experience heavy fishing pressure, had densities of 13-17 lobsters.100 m-2 of reef, which were similar to those in southern Africa.

One of the key differences between South African *P. homarus* habitats and those in Somalia, is the presence of large areas of deeper offshore reefs (6-15 m depth) which provide a refuge for lobsters in the former country. Since lobster fishing in South Africa is conducted either from the shore or by breathhold diving only, these reefs are not accessible to the majority of fishermen and the deeper water lobster population can continue to supply recruits to the accessible inshore areas. No lobster density estimates could be made in the southern Puntland area because of the antagonism of the fishermen, but in the northern area, searches by echo sounder revealed no deeper reefs and local lobster and shark fishermen had no knowledge of such areas. Thus much of the lobster stock appears to be located in very shallow water and is accessible by all types of fishing gear. Since there are no controls on the amount or kind of lobsters captured, the escalating fishing pressure will almost inevitably result in a decline in total catch and CPUE.

Although considerable poaching occurs in southern African *P. homarus* stocks, in KwaZulu-Natal there is a healthy recreational fishery of about 150 tonnes p.a. and lobsters are harvested mainly by divers who may not use boats or artificial breathing apparatus. In Transkei, most lobsters are caught by artisanal fishermen who operate from the rocks with baited lures and catch about 50 tonnes p.a. (Robertson & Fielding 1997). There is a minimum legal size of 65 mm CL with size at maturity at approximately 55 mm CL, and a bag limit of 8 lobsters per day in KwaZulu-Natal and five per day in Transkei. More importantly perhaps, there is a closed season of four months over the main breeding period, and egg bearing lobsters may not be captured at any time. Although the enforcement of compliance with these regulations is sometimes problematical, both fisheries are currently in a fairly healthy state. Perhaps one of the main contributing factors is that, although artisanal Transkei fishermen sell their catches to tourists, there is no industrial fishery for *P. homarus* in South Africa, and this means that no return on any capital investment drives the fishery to produce ever greater quantities of lobster.

The total stock size estimated for the Puntland coast between Foar and Eyl was 1 200 600 million lobsters or 264 tonnes. This would appear to be an underestimate, since the total annual catch has apparently been in the region of 500 tonnes in past years. However, from informal conversations with traders, the catches for the 1998/99 fishing season appear to be very depressed compared with previous years, and it will be of interest to obtain figures for the final catch weights. When calculating the total number of lobsters from the product of density and reef area, the estimate of total reef area is clearly the factor that most affects the calculation of the total number of lobsters. If the density was actually double our estimate of 4 lobsters.100 m-2 of reef, there would only be an extra 264 tonnes of lobster (i.e. a total of 528 tonnes of lobsters). The assumption made in this survey was that reef area only extended 100 m offshore along the entire coast. A more detailed bathymetric survey may well reveal lobster bearing reef further offshore, and fishermen and traders in the southern areas of Eyl and Gar'ad indicated that they used SCUBA gear to dive on reefs too deep for breathhold diving.

Catch size composition

There are no size limitations on lobsters captured by Somali fishermen. However, the mean sizes of 59 mm CL for females and 62 mm CL for males and modal sizes of 60-65 mm CL for both sexes, (Table 1) indicate that the tangle net fishery that operates in October and November catches animals that have just reached maturity. Thus the gear used in the short fishing season (nets with a 90-140 mm stretched mesh) would appear to set a partial size limit on the lobsters captured, that is compatible with a managed fishery, since generally minimum sizes in a fishery are set at the size at 50% maturity. Superficially it might be argued that the fishery should be sustainable and no other management is required since many females have a chance to reproduce before they are captured, and recruitment failure is unlikely. However, despite this gear limitation on the size of lobster captured, 52% of the female lobsters caught by tangle nets were smaller than the size at which they mature. In addition, no data were collected from the trap fishery that operates for the longer season between February and April. The traps used have no escape gaps and it is highly likely that the mean and modal sizes of lobsters captured by traps are considerably smaller than those for the tangle net fishery. Thus the average size of lobsters captured over a whole fishing season may well be substantially smaller than the size at maturity. In addition, the fishery operates over the main lobster breeding season (October/November). Slightly more than 40% of the female lobsters (58 mm CL that were captured by fishermen were actually carrying eggs, and these eggs have no chance to hatch once the animals are removed from the water. The average size of lobsters harvested at various localities in Oman in 1988/89 ranged from 62-82 mm and there was a minimum legal size of 80 mm CL (very weakly enforced) but this has not prevented the stock from showing signs of collapse (Johnson & Al-Abdulsalaam 1991). This is probably also attributable to the fact that berried females are retained in the catch. In Yemen all lobsters, regardless of reproductive condition are also retained in the catch and again there have been major declines in catches, even though the modal size of the catch was 130 mm tail length (70 mm CL) for males and 150 mm tail length (73 mm CL) for females between 1980 and 1983 (Sanders & Bouhlel 1984).

Unfortunately there are no data on mean sizes of lobsters harvested in the early years of the Somalia fishery, although fishermen generally agreed that lobster sizes had decreased, and that fewer large lobsters are now caught. It is interesting to examine differences in the size composition of the total catch in the north-western Indian Ocean assuming that lobsters caught in Oman, Yemen and Somalia all constitute a single stock. In 1988/89, 46% of the catch in Oman was larger than the minimum legal size of 80 mm CL and during the previous season approximately 90% of the catch was (80 mm CL (Johnson & Al-Abdulsalaam 1991). During 1994-95, the mean lobster sizes in the eastern sector of the Oman fishery were very much smaller (66-72 mm CL) than in the central and western sectors (79-88 mm CL; Mohan 1997). In Yemen, modal size was 70-75 mm CL in 1980-83 (Sanders & Bouhlel 1984). In Somalia, mean size was 60 mm in 1998. This could indicate a contracting size structure in the population as a whole because of fishing, but is more likely the result of natural geographical variation in size as a result of differences in sublittoral topography, monsoonal upwelling and related oceanographic and ecological conditions (Mohan 1997). In South Africa, the modal sizes are 70-75 mm CL and 65-70 mm CL for males and females respectively, in a relatively lightly exploited population of the same species, which probably has a slower growth rate than the northern stock.

Catch and CPUE

Considerable difficulties were experienced in obtaining meaningful CPUE data for the Somalia lobster fishery. This was mainly because a unit of effort was almost impossible to define. Some boats and their crew fished for themselves, while other boats both fished for themselves and collected lobsters from shore-based fishermen who were too far away from a processing station to transport their catches on foot. A third group of boats was used only to collect lobsters from shore fishermen, and some boats delivered lobsters to offshore trawlers. Nets are not always set daily, and if catches are good the nets are left in place while lobsters are removed by diving. It was also not clear how many fishermen operated a set of nets. Some boat fishermen operate both lobster nets and shark gill-nets and there is no way of determining how much time is spent on each fishery. During the October/November fishing season tangle-nets are almost exclusively used to catch lobsters and there is no trap fishery, but similar problems in defining a unit of effort are likely to arise in the February/March/April trap fishing season. Daib & Helder (1995) reported catches of 2.5-3.8 kg per lobster pot (presumably per trap haul), but the times between successive clearings of the lobster pots are highly variable. It is clear however, that the lobster fishing effort along the east coast of Somalia is very high, with over four fishermen per kilometre of coast. This is a similar figure to the effort in the rock and surf fishery along the KwaZulu-Natal coast, which is considered heavily exploited (Brouwer et al. 1997). It is also clear that CPUE has declined considerably in the Somalia lobster fishery and a mean catch of 1.5 kg lobster/man/day seems a very low rate of return for fishing that is conducted in extremely harsh conditions. Average boat catches estimated from boat skipper interviews were about 34 kg per boat per day and informal talks with traders in the Eyl area indicated boat catches of 25-35 kg per boat per day in 1998. However, traders recalled that boats would commonly return with 125 kg of lobsters after a day's fishing in the early 1990s, and catches as high as 250 kg per boat per day were reported. It is of interest that CPUE reported for the Yemen lobster fishery after at least 10 years of fishing were in the region of 6-25 kg/boat/day and 2-10 kg/net/day, using very similar fishing gear, boats and crew numbers (Sanders & Bouhlel 1984). In 1982/83, total Yemen catches appeared to be only 30% of the catches recorded in 1972/73 (Sanders & Bouhlel 1984). Unfortunately no detailed information on the history of the Oman fishery was available, but Johnson & Al-Abdulsalaam (1991) indicated that in some areas the fishery was showing signs of collapse. It is clear that the entire stock of *P. homarus* in the north-western Indian Ocean has been heavily exploited and catch rates have declined markedly. While some decline in catch rates is inevitable in any fishery once the "mining" phase of accumulated stock is over, serious attention needs to be given to all three lobster fisheries in order to prevent a major collapse because of possible recruitment overfishing. It should also be noted that the Yemen and Oman fisheries may have survived heavy exploitation pressure before the 1990s because the lightly exploited Somalia population continued to provide recruits by way of the current gyres in the region. Now that the Somalia population is also heavily fished, the number of recruits may be greatly diminished.

No CPUE effort values were available from the start of the Puntland lobster fishery but most fishermen agreed that a catch of 1.5 lobster/man/day was considerably lower than in the late 1980s when the fishery first started. This highlights the importance of monitoring in any fishery in order to follow trends in abundance of the stock so that informed management decisions can be made. There is also little available information on the total weight of lobsters caught annually in the Puntland region. The only estimate was that about 200 tonnes of lobster tails were exported annually from Bosaso airport (this would be equivalent to about 500 tonnes total weight). However, these catch estimates were from previous years and it was clear from conversations with traders that the catch in the 1998 season had declined considerably. Yet again the importance of keeping accurate catch records is emphasized in this regard. A similar decline in catches has been recorded in the *P. homarus* fisheries in Yemen and Oman. In 1972/73, at least 565 tonnes (whole weight) of lobsters were caught by Yemen fishermen selling to the Mukalla Cold Store, but within six years, catches had declined to approximately 150 tonnes (Sanders & Bouhlel 1984). In the Sultanate of Oman, landings increased from 15 tonnes in 1981 to 2400 tonnes in 1985 and 3000 tonnes in 1986, but the size structure of the population has changed dramatically and mean size of captured lobsters has diminished (Johnson & Al-Abdulsalaam 1991). It is of interest that peak catches in Oman (2000-3000 tonnes p.a.) are so much higher than in Yemen or Somalia, where the largest annual catches appear to have been 500-600 tonnes, despite the fact that fishermen in all three areas appear to fish with similar gear. Somalia has a considerably shorter coastline (+400 km) along which *P. homarus* occurs, compared with Yemen or Oman (+800-1100 km), which could account for lower total catches. Nevertheless it would appear that either lobster densities were considerably greater in Oman than elsewhere, or that there is considerably more suitable reef area in deeper waters in Oman, than in either Somalia or Yemen.

Size at maturity

The size at which 50% of Somalia female lobsters are mature (58 mm CL) is very similar to the value calculated by Berry (1971) for *P. homarus* along the east coast of South Africa, where female lobsters attain sexual maturity at 54 mm CL. If maturity is age related rather than size related, a probable faster growth rate because of warmer water temperatures would account for the slightly larger size at maturity in the northern animals. No data were obtained regarding ovarian development, but in southern African *P. homarus*, the majority of females have developing ovaries at a carapace length of 51 mm and this is probably true for the Somalia stock as well. A substantial number of females (25%) are reproductively active at 50-55 mm CL and even the 45-50 mm size class contributes to the spawning biomass of the population. De Bruin (1962) estimated that a Sri Lankan population of *P. homarus* attained sexual maturity at 55-59 mm CL while Jayakody (1989) estimated a size at oviposition of 59.5 mm CL for the same stock. George (1963) suggested that maturity occurred at a carapace length of 60-70 mm for lobsters along the coast of Aden (now south Yemen). All these values are very similar to the value calculated for Somalia lobsters. Although the size at maturity for male lobsters was not determined, it is probably very similar to that of females (Berry 1971).

However, there are some anomalies when other determinations of size at maturity for the lobster population in the north-western Indian Ocean are compared with this study. Johnson & Al-Abdulsalaam (1991) reported a size at 50% maturity of 80-85 mm CL for *P. homarus* off the coast of Oman and although a few females matured and carried eggs at 55 mm CL, less than 5% of the female population < 70 mm CL was mature. Off the Yemen coast, Sanders & Bouhlel (1984) estimated mean size at 50% maturity as 132 mm tail length, which is equivalent to a carapace length of 65 mm (Table 2). More recently, Mohan (1997) reported a wide variation in the size at maturity for *P. homarus* in Oman, ranging from 69-76 mm CL. It is not clear why there are these discrepancies, since lobsters in the Somalia-Yemen-Oman area are likely to constitute a single stock. Geographical variation in the size at maturity has been described for other Palinurid species (Pollock 1982,1991; Beyers & Goosen 1987; Jayakody 1989; Groeneveld & Melville-Smith 1994), with temperature variations, differences in population densities, habitat and food availability being the most commonly advanced explanations. It should be noted however, that Johnson & Al-Abdusalaam (1991) and Sanders & Bouhlel (1984) and possibly Mohan (1997) examined lobsters throughout the fishing season, while this study concentrated on lobsters only during the peak reproductive period. *P. homarus* are almost certainly repetitive breeders, (Berry 1971; Sanders & Bouhlel 1984), but only larger females produce more than one brood a year (Berry 1971). If the smaller lobsters breed only during a short period of the season, and the incidence of egg bearing in each size class is recorded throughout the fishing season, it is possible that the size at which 50% of lobsters appear to attain maturity will be skewed towards the larger size classes which breed throughout the year.

The timing of the breeding season for lobsters in the north-western Indian Ocean is of some interest. Presumably the stock responds to oceanographic events that improve the breeding success of the species. In subtropical and tropical Palinurids, female lobsters incubate eggs for approximately one month (Berry 1971). After hatching, the free floating larvae spend at least 4-6 months drifting in oceanic currents before metamorphosing into strong-swimming pueruli that revert to an inshore benthic existence. On the east coast of Somalia, the current system that must influence floating larvae is complex. When it encounters the east coast of Africa, the Southern Equatorial current forms a northward flowing current, the East African Coastal Current which becomes the Somali Current. This current is influenced by the changing monsoon winds of the north-western Indian Ocean. From October to March the north-east monsoon slows the northerly water movement and eventually reverses the current direction (Sommer, Schneider & Poutiers 1996; Baars et al. 1998). Larvae hatched in November/ December in Somalia, Yemen or Oman coastal waters would drift slowly southwards, since the current is relatively weak (Fowler 1987). By March the south-west monsoon winds have developed, which reinforce the East African and Somali Currents and drive the water strongly in a north-easterly direction. Between 5° and 9° N the Somali Current leaves the coast, turning eastward to create a clockwise gyre which brings some of the water back in the direction of the Southern Equatorial Current. The north eastward flowing Somali current also generates upwelling and consequent high productivity in the region of the Horn of Africa at that time (Sommer, Schneider & Poutiers 1996; Baars et al. 1998). Larvae driven northward in their later stages of development would become entrained in the gyre thus remaining in the general coastal areas of Somalia, Yemen and Oman, which would probably improve their chances of successful settlement. These late stage larvae would presumably also benefit nutritionally from the high productivity engendered by upwelling in the area.

Sex ratio

The overall sex ratio of lobsters examined from the commercial catch was 1:1.3 female:male. However, almost 80% of the commercial catch data were collected at Benda Beyla. Catches were skewed more strongly in favour of males at Bur Bur (1:1.4 F:M) and Dudura (1:2 F:M; Table 1). It is not clear why more males than females are caught in the fishery. In the Oman fishery the sex ratio was also 1:2 in favour of males (Johnson & Al-Abdulsalaam 1991) and Mohan (1997) recorded F:M ratios of between 1:1.1 and 1:1.4. In the very early years (1963) of the lobster fishery in what is now Yemen, a ratio of 2.34 males to 1 female was recorded by George (1963) between March and April, during which time 40% of the females carried eggs. In both *P. homarus* fisheries in South Africa the sex ratio was not significantly different from 1:1 (Berry 1971; Smale 1978; Fielding et al. 1994; Fielding 1997). One possibility is that, for oceanographic reasons, much of the fishing for *P. homarus* in the north-western Indian Ocean takes place over the lobster breeding season between October and March, while the South African fisheries are closed over the breeding season. Female lobsters incubating eggs may be less inclined to feed and thus be less susceptible to capture by both traps and nets, since both fishing gears function because of the feeding behaviour of lobsters. There is also the possibility of single sex aggregations of lobsters that might account for the skewed sex ratios. At Bur Bur, Dudura and Benda Beyla, sex ratios were all skewed in favour of males, but at Barmadobi there were three females for every male captured (Table 1). No single sex aggregations in South African *P. homarus* populations have been reported and the sex ratio is invariably close to 1:1 (Berry 1971; Smale 1978; Berry & Smale 1980; Fielding et al. 1994; Fielding 1997). Thus the large number of females in the sample from Barmadobi is unusual. No information was obtainable on sex ratios for the species in India and Sri Lanka.

Morphometric relationships

The CL/Whole weight relationships of the Somalia *P. homarus* stock are very similar to those of the species along the KwaZulu-Natal coast in South Africa (Berry 1971). Female Somalia lobsters are 6-9% heavier for an equivalent CL than South African female lobsters, but there is almost no difference in the comparative weights of male lobsters from the two countries. Since the width of the second abdominal segment in Somalia female lobsters is slightly greater than that of the South African stock, the greater weight per unit CL in the former is probably associated with a heavier abdomen which may result in slightly greater fecundity in the northern stock. There is very little difference in most of the other relationships given in Table 2 and those described by Berry (1971) for P. homarus along the South African coast. However, there are quite marked differences in the CL/Total length and CL/Tail length relationships of *P. homarus* from northern and southern Africa (Berry 1971; this study) and *P. homarus homarus* from Sri Lanka (Jayakody 1989). For a given carapace length, the Sri Lankan subspecies has a considerably shorter total length and tail length in both males and females than the African subspecies.

Growth, mortality and yield- and egg-per-recruit

One of the problems with yield- and egg-per-recruit modeling is that the results are highly sensitive to the biological parameters that are used in the modelling process. Furthermore, it is often difficult to obtain these parameters without a lengthy sampling programme. In the Somalia lobster fishery there are no data on growth rates and natural mortality, which are two of the key input parameters required. However, the growth coefficients used in the model were calculated for Yemen lobsters which probably form part of the same stock, and they are comparable to those for other tropical Palinurid lobsters (Ebert & Ford 1986; Haughton & King 1988; Suman et al. 1994). K values of 0.37 - 0.41.y-1 were estimated for *P. homarus* in Sri Lanka (Jayakody 1991) while Mohammed & George (1968) estimated a growth coefficient of 0.62 - 0.72 for Indian coast animals. Smale (1978) and Fielding (1997) calculated lower growth coefficients (0.18 - 0.34) for *P. homarus* in the cooler waters along the coast of southern Africa. Natural mortality is extremely difficult to determine, but values of M = 0.4 -1.03 have been recorded for tropical and sub-tropical shallow water lobsters (Smith & van Nierop 1986; Jayakody 1993; Baisre & Cruz 1994; Brown & Philips 1994; Polovina 1994; Evans & Evans 1996). Thus the values for the biological parameters used in the yield- and egg-per-recruit model appear to be reasonable.

Total mortality Z ranged between 1.84 for females and 2.70 for males. These values are high for a lobster fishery and imply a current fishing mortality of at least 1.00 - 2.10, depending on the value of M (since Z=F+M). While F = 2.00 may be somewhat unreasonable, it is not unlikely that the Somalia lobster fishery is operating somewhere between F = 1.0 and F = 1.5. It should be of interest to administrators, fishermen and traders that the yields would be improved by 30-50% at this level of fishing effort if small lobsters were returned to the water and only lobsters >60-70 mm CL were retained. Of more importance is the highly beneficial effect a minimum size of 60 mm CL would have on long-term egg production. A fishery based on a minimum legal size of 60 mm CL would be fairly robust to the effects of fishing in terms of maintaining a sufficient spawning stock, and would probably ensure the continuation of the lobster fishery at current levels. Assuming F = 1-1.5, a 60 mm CL size limit on the capture of females would ensure that egg production of at least 20% of the original unharvested levels was maintained in the lobster fishery (Table 5). A reduction in the egg production per recruit to 10% of unfished levels is internationally considered to constitute overfishing (Addison 1997; Punt & Kennedy 1997). In several lobster fisheries, target levels for egg production are about 20% of the pristine levels (Brown & Phillips 1994; Hobday & Ryan 1997;Muller et al. 1997) and this appears to allow the fisheries to operate sustainably.

CONCLUSION

The lobster fishery along the east coast of Somalia has been subjected to heavy fishing pressure over the last seven or eight years and this trend looks likely to continue. Stocks appear to have been depleted since catch rates have declined significantly and few large lobsters are now caught. Almost the entire stock appears to be accessible to fishermen and there are probably few unfished refuges. Aggravating the problem of high effort levels is the retention of all lobsters regardless of size or breeding condition, and the conduct of the fishery over the main lobster spawning season. The analyses conducted in this report suggest that egg production is currently about 10% of the level before exploitation began, and in most lobster fisheries this is generally regarded as an unsafe level. It has been suggested here that the implementation of a minimum size limit of 60 mm CL and the return of berried lobsters to the water, would have considerable benefits, from the perspectives of both the yield that could be obtained from the fishery and the improvements in egg production. The latter would reduce the risk of recruitment failure. These measures would certainly lead to a decline in catches in the short term, and this often leads to conflict among fishery users, who have trouble accepting that catch reductions can lead to better economic conditions. However, such situations have been resolved before, principally by bringing the fishermen into the management decision making process (Bree & Kendrick 1997). In the case of the Somalia fishery, this process was started by holding a workshop in November 1998, at which fishery users were invited to decide on the most acceptable management proposals. A number of direct and indirect control measures were proposed by the workshop participants. After voting, the most acceptable controls were the imposition of a minimum size limit of 60 mm CL, a limitation on gear types used, particularly with reference to the mesh size of tangle nets, and the return of berried lobsters to the water. If these measures are successfully implemented, it is highly likely that the lobster resource on the east coast of Somalia can be fished sustainably. However, it is important for resource users to realise that catches are unlikely to reach the levels achieved in the early years of the fishery. This is simply because in the early years of a fishery, the accumulated biomass of large animals is removed in what is often termed a “mining” phase, and catches and catch rates are likely to be particularly high. Thereafter, the fishery relies on the annual productivity of the stock to replace those animals caught the previous year, and the sustainable offtake is limited by that productivity.

It is also important to note that, although the *P. homarus* populations along the Somalia, Yemen and Oman coast are probably all part of a single stock, there appear to be considerable differences in the size at which females attain maturity in these three populations. Thus if minimum size limits are proposed as a management tool, the size limitation must be tailored to the respective areas.

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REFERENCES

ADDISON, J.T. 1997 – Lobster stock assessment: Report from workshop 1. Mar. Freshw. Res. 48 (8): 941-944.

BAISRE, J.A. and R. CRUZ 1994 - The Cuban Spiny Lobster Fishery. In: Spiny Lobster Management. Phillips, B.F., Cobb, J.S. and J. Kittaka (Eds). Fishing New Books, Oxford, 119-132.

BAARS, M.A., SCHALK, P.H. and VELDHUIS, M.J.W. 1998 – Seasonal fluctuatuins in plankton biomass and productivity in the ecosystems of the Somali Current, Gulf of Aden, and Southern Red Sea. In: Large Marine Ecosystems of the Indian Ocean: Assessment, Sustainability and Management. Sherman, K., Okemwa, E.N. and Ntiba M.J. Blackwell Science, 143-175.

BERRY, P.F. 1971a - The spiny lobsters (Palinuridae) off the east coast of southern Africa: distribution and ecological notes. Investl Rep. Oceanogr. Res. Inst. S. Afr. 27: 1-23.

BERRY, P.F. 1971b - The biology of the spiny lobster *Panulirus homarus* (Linnaeus) off the east coast of southern Africa. Investl Rep. Oceanogr. Res. Inst. S. Afr. 28: 1-75.

BERRY, P.F. and M.J. SMALE 1980 - An estimate of production and consumption rates in the spiny lobster *Panulirus homarus* on a shallow littoral reef off the Natal coast, South Africa. Mar. Ecol. Prog. Ser. 2: 337-343.

BEYERS, C.J. de B. and P.C. GOOSEN 1987 – Variations in fecundity and size at sexual maturity of female rock lobster Jasus lalandii in the southern Benguela ecosystem. In: The Benguela and Comparable Ecosystems: A.I.L. Payne, J.A. Gulland and K.H. Brink (Eds.). S. Afr. J. Mar. Sci. 5: 513-521.

BREE,P.A. and KENDRICK T.H. 1997. A fisheries management success story: the Gisborne, New Zealand, fishery for red rock lobsters (Jasus edwardsii). Mar. Freshw. Res. 48(8): 1103-1110.

BROWN, R.S. and B.F. PHILLIPS 1994 - The current status of Australia's rock lobster fisheries. In: Spiny Lobster Management. Phillips, B.F., Cobb, J.S. and J. Kittaka (Eds). Fishing New Books, Oxford, 33-63.

BURBRIDGE, P.R. 1987 – Sectoral report on coastal areas, development and management. In: Coastal and marine environmental problems of Somalia. UNEP Regional Seas Reports and Studies 84: 131-187.

BUTTERWORTH, D.S., PUNT, A.E., BORCHERS, D.L., PUGH, J.G. and G.S. HUGHES 1989 - A manual of mathematical techniques for linefish assessment. Rep. S. Afr. Natn. scient. Progms. 160: 83pp.

DE BRUIN, G.H.P. 1962 – Spiny lobsters of Ceylon. Bull. Fish. Res. Stn. Ceylon 14: 1-28.

DIAB, A. and K. HELDER 1995 - Evaluation report on lobster fishing in Bender Beyla from 20 March 1995 - 15 April 1995. OTP/SoHo Unpublished Report, Bosaso, Somalia.

CHARTERS, R. and C. CHAMPAGNE 1997 – Rehabilitation of the fisheries sector in Somaliland. Project proposal prepared by COOPI for the IUCN. 226pp.

EBERT, T.A. and R.F. FORD 1986 – Population ecology and fishery potential of the spiny lobster *Panulirus penicillatus* at Enewatak Atoll, Marshall Islands. Bull. Mar. Sci. 38: 56-67.

EVANS, C.R. and A.J. EVANS 1996 - A practical field technique for the assessment of spiny lobster resources of tropical islands. Fisheries Res. 26: 149-169.

EVERETT, G.V. and K. KELLEHER 1998 - Approaches to marine fisheries governance in Somalia, Annex II - Sectoral report on fisheries. FAO TCP/SOM/6713: 40pp.

FIELDING, P.J. 1997 – Stock assessment and fisheries management of the Natal rock lobster *Panulirus homarus*. Unpublished Report Oceanogr. Res. Inst. Durban. 140: 13-19.

FIELDING, P.J., ROBERTSON, W.D., DYE, A.H., TOMALIN, B.J., VAN DER ELST, R.P., BECKLEY, L.E., MANN, B.Q., BIRNIE, S., SCHLEYER, M.H. and T.A. LASIAK 1994 - Transkei coastal fisheries resources. Special Publication Oceanogr. Res. Inst. Durban. 3: 1-175.

FOWLER, S.W. 1987- Sectoral report on marine pollution. In: Coastal and marine environmental problems of Somalia. UNEP Regional Seas Reports and Studies 84: 1-20.

GAYANILO, F.C., SPARRE, P. and D. PAULY 1996 – FAO-ICLARM stock assessment tools: User's manual. Food and Agriculture Organisation of the United Nations, Rome. 1-126.

GEORGE, R.W. 1963 - Report to the Government of Aden on the crawfish resources of the Eastern Aden Protectorate. Expanded programme of technical assistance, Food and Agriculture Organisation, Rome, Report No. 1696: 1-23.

GROENEVELD, J.C. and MELVILLE-SMITH 1994 – Size at onset of sexual maturity in the south coast rock lobster *Palinurus gilchristi* (Decapoda: Palinuridae). S. Afr. J. Mar. Sci. 14: 219-223.

HAAKONSEN, J. M. 1983 - Samalia's Fisheries Case Study. Somalia Academy of Sciences and Arts, Mogadiscio, Somalia. FAO Report: 170-184.

HAUGHTON, M.O. and D.P.F. KING 1988 - Population biology of the spiny lobster (*Panulirus argus*) in Jamaica waters. Proceedings of the 41st Annual Gulf and Caribbean Fisheries Institute: 528-542.

HOBDAY, D.K. and T.J. RYAN 1997- Contrasting sizes at sexual maturity of southern rock lobsters (*Jasus edwardsii*) in the two Victorian fishing zones: implications for total egg production and management. Mar. Freshw. Res. 48 (8): 1009-1014.

JAYAKODY, D.S. 1989 - Size at onset of sexual maturity and onset of spawning in *female Panulirus homarus* (Crustacea: Decapoda: Palinuridae) in Sri Lanka. Mar. Ecol. Prog. Ser. 57: 83-87.

JAYAKODY, D.S. 1993 - On the growth, mortality and recruitment of the spiny lobster (*Panulirus homarus*) in Sri Lanka waters. Naga (Philippines) ICLARM, 16(4): 38-43.

JOHNSON, D.W. and T.Z. AL-ABDULSALAAM 1991- The scalloped spiny lobster (*Panulirus homarus*) fishery in the Sultanate of Oman. The Lobster Newsletter, 4(1): 1-4.

LOVATELLI, A. 1995 – Artisanal fisheries. Final report, EC Rehabilitation Programme for Somalia, EC Somalia Unit, Nairobi.

MOHAMMED, K.H. and M.J. GEORGE 1968 - Results of the tagging experiments of the Indian spiny lobster *Panulirus homarus* (Linn.) - movement and growth. Unpublished Report, Australian/New Zealand meeting on decapod crustacea, Sydney, October 24-28, 1967, 1-12.

MOHAN, R. 1997 – Size structure and reproductive variation of the spiny lobster *Panulirus homarus* over a relatively small geographic range along the Dhofar coast in the Sultanate of Oman. Mar. Freshw. Res. 48 (8): 1085-1092.

POLLOCK, D.E. 1982 – The fishery for and population dynamics of west coast rock lobster relate to the environment in the Lamberts Bay and Port Nolloth areas, South Africa. Sea Fisheries Investgl. Rep. 124: 1-57.

POLLOCK, D.E. 1991 – Spiny lobsters at Tristan da Cunha, South Atlantic inter-island variations in growth and population structure. J. Mar. Sci. 10: 1-12.

POLOVINA , J.J. 1994 - The lobster fishery in the north-western Hawaiian Islands. In: Spiny Lobster Management. Phillips, B.F., Cobb, J.S. and J. Kittaka (Eds). Fishing New Books, Oxford, 83-90.

PUNT, A.E. and R.B. KENNEDY 1997 – Population modelling of Tasmanian rock lobster *Jasus edwardsii*. Mar. Freshw. Res. 48 (8): 967-980.

ROBERTSON, W.D. and P.J. FIELDING 1997 – Transkei coastal fisheries resources Phase II: Resource utilisation, development and tourism. Special Publication Oceanogr. Res. Inst. Durban. 4: 1-166.

SANDERS, M.J. and M. BOUHLEL 1984 - Stock assessment for the rock lobster (*Panulirus homarus*) inhabiting the coastal waters of the People's Democratic Republic of Yemen. FAO Report, May 1984, 1-67.

SMALE, M.J. 1978 - Migration, growth and feeding in the Natal rock lobster *Panulirus homarus* (Linnaeus). Investl Rep. Oceanogr. Res. Inst. Durban, S. Afr. 47: 56pp.

SMITH, G.B and M. VAN NIEROP 1986 - Abundance and potential yield of spiny lobster (*Panulirus argus*) on the Little and Great Bahama Banks. Bull. Mar. Sci. 39(3): 646-656.

SOMMER, C., SCHNEIDER, W. and J-M. POUTIERS 1996 – The living marine resources of Somalia. Food and Agricultural Organisation of the United Nations, Rome, 1-376.

STROMME, T. 1987 - Annex IV - Sectoral report on marine living resources. In Coastal and marine environmental problems of Somalia. UNEP Regional Seas Reports and Studies, 84: 87-110.

SUMAN, A., SUBANI, W. and P. PRAHORO 1994 - Some biological parameters of blue-green spiny lobsters (*Panulirus homarus*) in Pangandaran waters, West Java. J. Mar. Fish. Res. 85: 1-8.

APPENDIX 1: PROCEEDINGS OF THE PUNTLAND LOBSTER MANAGEMENT WORKSHOP (IUCN, OTP & ORI) BOSASO, SOMALIA, 25-26 NOVEMBER 1998

Background

Since the late 1980s lobster stocks along the Puntland coast of Somalia (Foar to Eyl or Hafoon to Gara'ad) have become an increasingly important source of livelihood to local communities. Lobster are harvested by artisanal fishermen off boats and from the shore using traps, gill-nets, cast-nets and by diving with hand-held spears. Harvested lobster are then tailed and packed into freezer trucks at coastal processing stations before being driven to Bosaso Airport for export to Dubai in the United Arab Emirates. Since the end of the civil war in Somalia in 1992, more and more people have moved to the coast to participate in this lucrative fishery. The substantial increase in fishing effort has led to dramatically reduced catches and concern has been expressed about the sustainability of the fishery.

The situation was brought to the attention of the Somali Natural Resources Management Programme, Eastern Africa Regional Office of the World Conservation Union (IUCN). The IUCN then contracted Ocean Training & Promotions (OTP - a Dutch backed, Somali NGO) and the Oceanographic Research Institute (ORI - a South African NGO) to conduct an assessment of the status of the lobster stocks and to provide options for improved management of the fishery. OTP staff, under the guidance of their Director - Abdullahi Daib, provided logistical support for the lobster assessment which included boats, diving gear, vehicles, accommodation, food etc. while two staff from ORI - Dr Peter Fielding and Mr Bruce Mann, undertook the diving survey and collected fishery catch statistics.

The purpose of this workshop was to provide feedback to fishermen, traders, village elders and politicians about the preliminary results of the survey, and to engage stakeholders in discussions that would hopefully lead to the implementation of feasible fishery controls to ensure the future sustainable use of the lobster resource.

Introduction

Dr Fielding welcomed all the participants and explained the purpose of the workshop (as above). He explained that the ORI was a marine research institute based in Durban, South Africa and that the organisation was primarily concerned with conducting applied marine research to ensure the sustainable use of marine resources and the conservation of marine biodiversity. As an organisation, ORI had considerable experience in Indian Ocean fisheries and had been involved in a variety of fishery projects in Kenya, Tanzania, Mozambique, South Africa and Namibia. He stressed that ORI was not a political organisation or an enforcement agency, but that the function of the institute was to provide scientific information and advice on fisheries assessment and management. The lobster survey had been conducted under difficult conditions and a few problems had been encountered. However, reasonable results had been obtained and Dr Fielding thanked OTP for providing logistical support and backup. With the current lack of government control and enforcement capacity in Puntland, it was clearly going to be up to the fishermen and traders themselves to take heed of the results of the lobster survey and to decide amongst themselves on how best to manage this fishery in the future.

A description of the lobster life cycle and an overview of some basic fisheries principles

Generalised life cycle of the rock lobster *Panulirus homarus*

A male lobster mates with a female by grasping her and pinning her against a rock and depositing a packet of sperm (the spermatophore) on the ventral side of the carapace (thorax). Once the female is ready to lay her eggs, she scrapes the spermatophore open with her back legs and the eggs are fertilised. The eggs are then attached to hairs on the pleopods under the abdomen where they remain for 3-4 weeks. A mature female of 60 mm CL (250 g) produces about 100 000 eggs per breeding season. Eggs that have just been fertilized are bright orange in colour but they become brown as they develop. Larvae then hatch from the eggs and are free floating (they cannot swim). The larvae spend 4-6 months floating in the sea and are widely distributed by currents off the Puntland coast. During this planktonic larval phase the larvae go through nine stages of development . The larvae then change into what looks like a very small lobster which is about 2 cm long and is a strong swimmer. These juveniles swim inshore and settle on suitable rocky reefs where they remain until they reach adulthood. It is important to point out that very few of the original number of eggs that hatch survive to the settlement stage because most of them are eaten by other animals during the planktonic stages. It is also important to note that this species of lobster (*P. homarus*) is found mainly on inshore rocky reefs and seldom occurs deeper than 20 m . They are therefore seldom caught in commercial trawling operations as large trawlers will not venture too close inshore and they will not trawl over rough rocky reefs where the chance of snagging and losing their trawl gear is high. Adult lobsters are bottom feeding predators which eat a variety of organisms including mussels, barnacles, limpets, urchins etc. which they crush with their strong jaws. Lobsters grow quite quickly and reach maturity ($\pm$ 60 mm CL or 250 g) in about 2-3 years when they are large enough to mate and produce eggs. Lobster (*P. homarus*) live for about 12 years (if they are not caught) with males growing larger than females. The largest male sampled during the survey was 115 mm CL (1 kg) and the largest female was 90 mm CL (650 g). In order to grow a lobster needs to shed its shell (moult). "Soft shell" lobster are individuals that have recently moulted and it takes approximately 2 days for the shell to harden. Adult lobster will moult two to four times a year.

Overview of some basic fisheries principles

It is necessary to understand some important principles which apply to any stock of animals be they camels, goats, fish or lobsters. Many people seem to think that because you cannot see what is happening in the sea the same principles on land do not apply, but they do. For example, if you owned a herd of 100 camels, 50 of which were males and 50 were females, and each female produced one calf per year, theoretically you could export 50 camels to Saudi Arabia each year on a sustainable basis. However, if only 30 calves were produced each year and you continued to export 50 camels every year, your herd of camels would gradually diminish until you had none left. Exactly the same basic principle applies to lobsters in the sea - if you catch more lobsters than are produced every year the stock will decline and catches will fall. In a stock of lobsters in the sea, adult lobsters breed every year and new lobsters are born and grow to be adults. This is called recruitment and growth which increases the number and weight of lobsters in the stock. At the same time lobsters die from natural causes (predation, disease etc.) and this is called natural mortality. Lobsters are also caught by fishermen and this is called fishing mortality. Both types of mortality reduce the number and weight of lobsters in the stock. In most fisheries the only thing you can control is the fishing mortality, in other words the amount of lobsters caught by fishing. It is also important to realise that the lobster stock is limited as it is only found on rocky reefs from the shore down to about 20 m depth which is an extremely narrow band along the Puntland coast.

Density estimates of Puntland lobster stocks

In order to know how to manage your stock (whether they are camels, goats or lobsters) you need to have an idea of how many animals you have got. While on land you can simply go out and count the animals, unfortunately it is not quite so easy in the sea.

3.1 Transecting methodology

The method used to survey the lobster stock along the Puntland coast is an accepted scientific method used in shallow water lobster fisheries around the world. It involves conducting underwater counts to estimate the average number of lobsters in a measured area of reef. A weighted transect line or chain of known length (10 or 20 m) was laid across the reef and a scuba diver swam along the line counting lobster one metre on either side of the line. This procedure was repeated as many times as possible at different sites along the coast in order to obtain good estimates of the number of lobsters in a measured area of reef.

Preliminary results

Initially we had planned to survey the entire coastline between Foar and Eyl but, because of problems experienced in the Eyl area, we were only able to work in the area between 10 km north of Barmadobe and Dudura which represents 132 km of coastline. We completed a total of 39 dives at different sites and covered an area of 12 185 m^2 of reef. We counted a total of 561 lobsters during the transects which gave an average density of approximately 4.6 lobsters per 100 m^2 of reef (estimates varied considerably from place to place ranging from 0 to 17 lobsters per 100 m^2 of reef). Based on this density estimate, we then estimated the entire lobster population between Foar and Eyl (300 km) assuming a 100 m strip of reef along the entire coast. This gave an estimate of 1.2 million lobsters or 300 tonnes of stock, assuming an average weight of 250 g per lobster.

These are the first preliminary estimates of the Puntland lobster stock and there are a number of very broad assumptions made in these calculations. For example, the assumption that there is a 100m wide strip of reef along the entire coastline is obviously not entirely true. However, extensive searches with an echo-sounder revealed very little offshore reef deeper than 10m. This suggests that most of the lobsters are in fact concentrated along inshore reefs. This was largely confirmed by the areas where lobster are caught, with most fishing being conducted in a narrow belt along the coastline. It is also relevant to point out that many areas along this coast have deep caves and overhangs at the base of the cliffs and poor visibility and strong surge made it impossible for us to dive in many of these areas. However, in the few instances where we were able to enter these caves we counted large numbers of lobsters, so it is possible that lobster densities may have been slightly under-estimated.

Lobster density comparison with other areas

It is useful to compare the above results with a similar lobster survey done on the same species (*P. homarus*) along the Transkei coast in South Africa. There is no commercial fishery for this species in South Africa and lobsters are only caught by recreational and subsistence fishermen mainly by free diving (no catching with spears, nets, traps or scuba gear is allowed). The lobster stock in Transkei is therefore in a relatively healthy state and a comparison of the results of a diving survey done in 1993 with those of the current study are shown in Table 1.

Table 1. A comparison between the results of lobster survey conducted in 1993 along the Transkei coast, South Africa with the results of the current survey done on the Puntland coast, Somalia in 1998.

	TRANSKEI, 1993	PUNTLAND, 1998
LENGTH OF COAST	211 km	300 km
LOBSTER DENSITY	18 lobster/100 m^2	4.6 lobster/100 m^2
TOTAL STOCK ESTIMATE	2.45 million lobster	1.2 million lobster

Although these are obviously very different areas with different current patterns, water temperatures and reef types, this comparison does suggest that the lobster population along the east coast of Puntland is considerably lower than it could be and it is clear that overfishing is the main reason for the reduced density of lobster. It is also interesting to note that our highest estimates of lobster density between Barmadobe and Dudura were obtained in areas furthest away from the fishing villages suggesting that where fishing effort is lower (due to the distance from collection points) lobster densities were higher. Again this clearly demonstrates the effect fishing is having on the lobster population.

Comments and questions

Partipants from Eyl and Gara'ad informed the workshop that there were extensive reef areas to the south of where the survey had been conducted and that lobster were often caught at depths of 20-25 m. Lobster divers in this area, some of whom operate using scuba, had reported signs of reef damage probably caused by trawling operations. The issue of foreign vessels trawling in Somali waters was extremely sensitive and the ORI and IUCN delegates present at the workshop were requested to do everything in their power to help prevent poaching by illegal vessels.

Size frequencies of harvested lobster

Methods

During the survey both ORI and OTP staff measured, sexed and determined stage of maturity of lobsters brought into the various processing stations every afternoon. The purpose for doing this was to establish the average size of lobster caught in the fishery, to determine the sex ratio (number of males and females) in the population, to determine the size at which lobsters mature and to establish when breeding takes place.

Results

A total of 2 500 lobsters were measured during the survey. The average size of lobsters measured was approximately 60 mm CL (or 250 g). This was very close to the size at which the lobsters reach maturity but about 30% of the catch consists of juvenile lobsters. These juvenile lobster have not yet had a chance to breed and the ability of the lobster stock to produce eggs is being reduced. Unfortunately, there is no data on the average size of lobster caught at the start of the Puntland lobster fishery but in most over-exploited lobster fisheries the trend is that the average size of lobster caught decreases over time. This highlights the importance of long-term monitoring of the fishery in order to follow the mean size of lobster caught . Overall, the sex ratio of the lobsters sampled was close to 1:1 (male:female). However, catches at some of the villages were dominated by one sex suggesting that there may be some separation of males and females in certain areas. The survey was conducted in November and a large number of the female lobster sampled were in berry (carrying eggs). Further discussions with fishermen suggested that October to December was the main breeding season for lobster although some breeding takes place throughout the year.

It is important to point out that the lobsters sampled were mainly caught in nets (gill-nets and cast-nets) and nets with larger mesh generally appeared to catch larger lobster. This is preferable in any fishery as it is better not to catch juvenile lobster because they grow very fast and also have not yet had a chance to breed. The size frequency of lobster caught in traps was not measured as traps are used mainly during the March-April season when lobster are feeding more actively. However, discussions with fishermen suggested that lobster of all sizes were caught in traps, particularly small lobster which are more abundant. Similarly, divers using hand-held spears also caught many small lobsters.

Catch per unit effort and estimates of total catch and effort

Methods and rationale

The term catch per unit effort (CPUE) simply means the catch taken by fishermen (in terms of number or weight) over a certain period of time using a certain gear type. For example if one fisherman fishing for one day using one net catches 10 lobster, his CPUE is 10 lobster/man/day. This catch rate can then be used as an index of abundance of the stock you are fishing. For example when a you first start fishing a stock of fish the CPUE is normally very high (i.e. there are a lot of fish), however, if you fish very hard and catch many of the fish the CPUE goes down (i.e. there are fewer fish in the stock and it takes longer and is harder to catch them). During the survey members of the OTP team interviewed fishermen to collect CPUE information.

Results

A total of 71 boat skippers were interviewed (46 at Bender Beyla and 25 at Barmadobe).The boats used varied in length from 6 to 8.5 m and most were driven by 15 to 30 Hp outboard motors and were crewed by an average of 5-6 crew. Gears used ranged from gill-nets, cast nets to diving using hand-held spears. The CPUE ranged from 0-200 kg lobster/boat/day with an average of 34 kg lobster/boat/day. However, because some boats also collected lobster from fishermen along the shore it was useful to look at catch per man per day. Results from 213 boat fishermen and 317 shore fishermen were obtained who caught a total of 824 kg of lobster. This gave an average CPUE of 1.5 kg lobster/man/day and each man was using an average of two nets. No CPUE effort values were available from the start of the Puntland lobster fishery but most fishermen agreed that a catch of 1.5 lobster/man/day was considerably lower than in the late 1980s when the fishery first started. Again this highlights the importance of monitoring the fishery in order follow trends in abundance of the lobster stock and to make informed decisions on how to manage it (this is similar to keeping good records in any successful business).

During the lobster survey counts were made of the total number of fishermen and boats seen fishing along the coast between Barmadobe and Dudura. From these counts it was possible to estimate that there were approximately 4.1 fishermen per kilometre of coast (including boat fishermen, shore fishermen and divers). Assuming this fishing effort occurs along the entire coast from Foar to Eyl (300 km), this would give a rough estimate of some 1 220 fishermen operating along this stretch of coast. If lobster fishermen fish for approximately 150 days per year (Oct, Nov, Feb, Mar, Apr) at the current CPUE of 1.5 kg lobster/man/day, the total annual catch would be in the region of 280 tonnes (whole weight).

Unfortunately, there was little available information on the total weight of lobster caught annually in the Puntland region. The only estimate was that about 200 tonnes of lobster tail was exported annually from Bosaso airport (this would be equivalent to about 500 tonnes total weight). However, these catch estimates were from previous years and it is clear that the catch in the 1998 season had dropped a lot. Yet again the importance of keeping accurate catch records is emphasized in this regard.

Comments and questions

A participant queried the use of CPUE as an index of stock abundance. He explained that if the number of fishermen continues to increase and the CPUE goes down this does not necessarily mean that the stock has been reduced but that it is simply being shared out between more and more fishermen. The ORI facilitators agreed that CPUE was a weak indicator of stock abundance in conditions of continually increasing effort and one also needed to look at trends in the total catch. Participants informed the workshop that in the region between Bargaal and Gara'ad approximately 350 tonnes tail weight of lobster had been exported during 1995. However, the total export for the October-November season during 1998 was only about 70 tonnes tail weight. Following a short discussion it was suggested that catch statistics should be obtained from the air transport companies who export the lobster tail.

Sustainability of the lobster fishery - modelling stock size and current fishing mortality

Methodology and rationale

As the survey had just been completed, there had not yet been enough time to thoroughly analyse the data collected. However, Dr Fielding briefly described how the data collected on the lobster fishery could be modelled to provide some idea of what level of fishing effort should be maintained to ensure the maximum catches of lobster on a sustainable basis. Modelling a fishery was compared to an engineer building a dam - first the engineer needs to build a model of the dam using mathematical equations to determine how much water the dam would hold, how strong the wall needed to be, how wide to make the spillway etc. From this model the engineer can design the best way to build the dam. In the same way you can build a model of a fishery to tell you what will happen if you have too many fishermen, or catch too many immature fish, or take too many females with eggs etc. The information needed to build such a model includes how fast the animals grow, how long it takes them to reach maturity, how many eggs an average female produces, the weight of an animal at a particular size and the size at which they begin to be caught in the fishery. Participants were then shown typical yield per recruit and egg per recruit curves and the following important points were made: a) catch does not go on increasing with increasing fishing effort but reaches a maximum and then may start to decline, b) by catching females the number of eggs produced by the population declines, c) if too many females are caught this may result in recruitment failure (not enough eggs produced to replace animals being removed by fishing).

Based on a preliminary analysis of the data collected it was concluded that the current level of fishing effort is very high, catches appear to be declining and it was speculated that the number of eggs being produced by the lobster population had probably been reduced to about 20% of the original level before lobster fishing started. This is very close to what is regarded as a dangerous level and if lobster were continued to be fished at the present rate its unlikely that enough eggs would be produced to sustain the fishery.

Results of the questionnaire survey on the current status of the lobster resource and the desirability of management controls

Methods

A short questionnaire designed by ORI and OTP staff was used to interview stakeholders about their attitudes and perceptions of the status of the lobster resource and the need for management controls. The interviews were conducted by OTP staff at some of the fishing villages visited.

Results

A total of 60 people were interviewed at Bender Beyla and Kulule including 5 elders, 13 traders, 14 boat skippers and 28 fishermen. On average these people had been involved in the lobster fishery for about 12 years. All the people interviewed said that the lobster catches had declined (by an average of 73%) and the main reasons for this decline were: increasing effort (38%), trawling by foreign vessels (22%), fishing continuously throughout the year (20%), catching of juvenile lobster and females in berry (9%) and various other reasons (11%). All the people interviewed agreed that there had been a big increase in fishing effort and 91% believed that some form of management control was necessary. Seventy-seven percent of interviewees felt that no juvenile (immature) lobster should be caught and 86% felt that lobster in berry should not be kept and sold. When asked if they would be prepared to return juvenile lobsters or lobsters in berry alive back to the water, 87% said they would. Interviewees were asked whether they thought that lobster fishing should be allowed to take place throughout the year and 46% felt that there should be some form of closed season. If there was a closed season implemented, 97% said that they would be able to fish for other resources or find other sources of income. Examples of other resources, or activities they could engage in if not fishing for lobster included: shark fishing (76%), herding livestock (12%), fishing for finfish (10%) and various other trades (2%). Finally none of the respondents interviewed knew of any areas along the coast that were not fished for lobster (i.e. *de facto* marine reserves).

Workshop session on the identification, feasibility and implementation of management options to improve the sustainability of the Puntland Lobster Fishery

To introduce the workshop session, The ORI facilitators briefly summarised the available information on the status of the Puntland lobster fishery as follows. Although the lobster survey had been a "snapshot" of the fishery and more information needed to be collected, a reasonable amount of information was now available on which to base sound decisions about the future of the fishery. The density of lobster off the Puntland coast was significantly lower than less exploited areas. There are a large number of fishermen and traders that have invested in the lobster fishery all of whom want to make a profit out of their investments. However, it is apparent that the lobster stock is low and the CPUE has decreased considerably. Total catches are much lower than when the fishery first started and it is likely that the number of lobster eggs being produced has dropped considerably. Interviews with stakeholders suggested that nearly everyone believed that some sort of management control was necessary and it is clear that the Puntland lobster fishery is running into trouble. The basic reason for this situation is that too many lobsters are being caught. In order to rectify this situation there are a number of ways to limit or control the number of lobster being caught or to fish the lobster stock more selectively to ensure that production remains as high as possible.

The workshop was then divided into five groups of 5-6 people to discuss possible management options which could be implemented to improve the fishery. A person from each group then reported back to the workshop as a whole. The following management options were put forward and they were separated into direct fishery controls and supporting structures and functions:

<u>A. Direct fishery controls</u>

i. Closed season - establishment of a closed season so that lobster fishing does not occur throughout the year (effort reduction)
ii. Limit the number of fishermen by implementing a licensing system (effort control)
iii. Control gear types used - control mesh size of nets used and introduce escape gaps for juveniles into lobster traps
iv. Minimum size limit - introduce a size limit (at or near the size at maturity) which is enforced by traders refusing to buy undersized lobster
v. Improve product quality - introduce blast freezers, cook whole lobster prior to sale or keep lobster alive in artificial cages prior to export
vi. Discourage catching and selling of berried lobster (traders to stop buying lobsters that are carrying eggs)
vii. Close lobster fishery for two years to allow stocks to recover
viii. Establishment of closed areas or marine reserves - to allow stock recovery and seeding of adjacent areas
ix. Setting of a total allowable catch (it was pointed out that a great deal of knowledge is required about the stock and fishery before such a measure could be implemented)
x. Habitat enhancement - for example the lobster shelters being used in Kenya
xi. Control of illegal fishing by foreign vessels

<u>B. Management support structures and functions</u>

- i. Establishment of government infrastructure to implement fisheries regulations
- ii. Set up and network local community-based structures and initiatives (e.g. fishing associations and committees)
- iii. Run fisheries awareness training courses and improve fisheries awareness at local and government level
- iv. Conduct scientific research into fisheries production (stock assessments) of lobster and other living marine resources
- v. Set up a fisheries monitoring system to collect relevant data important for sound management
- vi. Diversify fishing effort - encourage fishing for other marine resources and provide other employment opportunities for coastal communities
- vii. Traders to reduce credit provided to fishermen

Following this workshop session participants were asked to choose the most important management controls that they believed could be implemented under the current circumstances. After some discussion it was agreed to vote on which controls were most practical and implementable (Table 2).

Table 2. *Results of votes taken by 23 workshop participants on the most practical and implementable management controls for the Puntland lobster fishery (the three top management options chosen are shown with an asterix).*

MANAGEMENT OPTION	VOTES FOR	VOTES AGAINST
Closed season	11	12
Licence system	4	19
Improve product quality	18	5
Diversify fishing effort	16	7
Control of gear types*	18	5
Minimum size limit*	22	1
No taking of lobster in berry*	20	3
Close fishery for two years	1	22
Closed areas (marine reserves)	10	13
Total allowable catch	1	22
Habitat enhancement	10	13

Following the selection of the three options (marked above with an asterix) participants were asked to consider "HOW" these options could be implemented, "WHO" would do it and be responsible for the implementation and "WHEN" (what time frame) would implementation take place. The ORI facilitators pointed out that a minimum size limit should probably be set at about 60 mm CL (250 g) and all lobster caught under this size would have to be returned live to the water. All berried lobster caught would have to be returned live to the water. Mesh size of gill and cast-nets would have to be limited to about 100 mm stretched mesh (approximately 5 inch) and escape gaps for juvenile lobster would have to be built into all lobster traps. In the ensuing discussion the following action plan was decided:

- i. To improve awareness about the status and biology of the lobster resource (participants of the workshop to spread knowledge)
- ii. To develop community level rules regarding lobster fishing (community elders)
- iii. Traders to stop buying undersize lobsters and lobsters in berry in order to force fishermen not to catch them
- iv. To standardise fishing gears by stopping the provision and sale of small mesh nets.
- v. To introduce the concept of escape gaps in the making of lobster traps
- vi. Traders to set up a committee which will jointly decide on implementation of controls

The time frame set for the implementation of this management plan was by the forthcoming lobster season (March 1999).

Conclusion

Dr Peter Fielding (ORI) and Mr Alex Forbes (IUCN) concluded the workshop and thanked all the participants for attending and for their valuable contributions. The workshop had been extremely successful as a great deal had been learned, a practical action plan had been developed and a time frame set for its implementation. All present were encouraged to take the process forward and work towards developing a productive and sustainable lobster fishery which would bring maximum benefit to the people of Puntland. Abdullahi Daib and the OTP staff were thanked for organising the workshop venue. Workshop participants were asked to complete a short workshop evaluation form to enable improvement of future workshops of this nature. The workshop organisers and facilitators were thanked by an elder from Eyl on behalf of all the participants and he apologised for the hijacking incident that had taken place in Eyl during the lobster survey.

NAMES OF PARTICIPANTS:

Mohamed Abdulahi Farah	Durdura
Farah Hagi Mire	Kulule
Abdighani Yusuf Aw-muse	Kulule
Mohamoud Mohamed Ismail	Kulule
Ahmed Mohamed Jama	Kulule
Abdikadir Hassen Yusuf	Arris
Abdiaziz Mohamud Ismail	Durdura
Yusuf Omer Mohamed	ElDhidar
Abdirashir Dahran Mohamed	ElDhidar
Jama Haji Warsame Ahmed	Gara'ad
Abdirizak Farah Mohamed	Gara'ad
Mohamoud Abdi Omer (Adoyo)	Radio Galkayo
Ahmed Haji Hassen	Kulule
Said Mohamed Mouse	Gara'ad
Omer Mohamoud Irbad	Horn Relief
Mohamed Yusuf Mohamed	Bender Beyla
Isse Ahmed Ismail	Bender Beyla
Ali Farah Ali	UNDP/OPS, Bosaso
Abshir Mohamed Hussei	Bosaso
Abdirashid Nour Ibrahim	Bender Beyla
Abdirizak Hassen Mouse	LPI, Bosaso
Ali Abdi Aware	Bender Beyla
Salah Dahir Abdalla	Ministry of Fisheries, Bosaso
Paul Simkin	EC, Bosaso
Nanko Borsboom	Africa 70, Bosaso
Khalif Mohamed Barre	Kaaha Bari Press
Ismail Hassen Ali	Bender Beyla
Izak Abdisalam	Bosaso
Abdirahman Osman Ali	Gara'ad
Ladane Ali Jama	Kulule
Abdihakim Yassin Dabao	Foar
Mohamud Ali Ahmed	Bender Beyla
Foad Mohamed Omer	Bender Beyla
Ali Hierad Mohamed	Shilcon, Bosaso
Mohamoud Farah Mohamed	Shilcon, Bosaso
Hussein Daib Saed	Durdura
Abdisamed Mohamed	Sahan Press
Abdirizak Nour	Bosaso
Abdulhi Diab	OTP, Bosaso
Holden	OTP, Bosaso
Abdulisac	OTP, Bosaso
Abdulhi (Interpreter)	OTP, Bosaso
Mohamoud	OTP, Bender Beyla
Alex Forbes	IUCN, Nairobi
Tony Potterton	IUCN, Nairobi

Workshop Conveners: Peter Fielding and Bruce Mann, ORI, Durban, South Africa

PROGRAMME

Day one (25/11/1998)

1. Arrival and registration
2. Introduction and overview (OTP & ORI)
3. Density estimates of Puntland lobster stocks (ORI)
4. Lobster size frequency (ORI)
5. Tea
6. Catch per unit effort and estimates of total catch and effort (ORI)
7. Sustainability of the lobster fishery - modeling stock size and current fishing mortality (ORI)
8. Closure of proceedings of day 1

Day two (26/11/1998)

1. Brief summary and recap of day one (ORI)
2. Results of the questionnaire on stakeholder perceptions of the lobster fishery (ORI)
3. Workshop session on the identification of possible management options to improve the sustainability and productivity of the Puntland lobster fishery (all)
4. Tea
5. Workshop session on the development of a feasible management plan for the Puntland lobster fishery (all)
6. Workshop wrap-up and summary of key points (OTP and ORI)
7. Workshop closure

APPENDIX 2: FISH SPECIES LIST OBSERVED DURING THE SOMALIA LOBSTER SURVEY (BARMADOBE TO DUDURA) DURING NOVEMBER 1998

FAMILY	SPECIES	COMMON NAME	ABUNDANCE	METHOD
ACANTHURIDAE	*Acanthurus gahhm?*	Black surgeon	*	D
	A. nigricauda?	Epaulette surgeon	*	D
APOGONIDAE	*Apogon nigrofasciatus?*	Blackbar cardinalfish	*	D
	Sphaeramia orbicularis	Mangrove cardinalfish	*	D
ARIIDAE	*Arius thalassinus*	Giant catfish	*	D, N
BALISTIDAE	*Sufflamen fraenatus?*	Bridle triggerfish	***	D
BELONIDAE	*Tylosurus? sp.*	Garfish	*	D
CAESIONIDAE	*Caesio teres?*	Yellow and blue fusilier	*	D
CARANGIDAE	*Caranx sem*	Yellowtail kingfish	***	D, N, L
	Gnathodon speciosus	Golden kingfish	*	L
	Pseudocaranx dentex?	White kingfish	*	N
	Scomberoides commersianus	Largemouth queenfish	*	N
	S. lysan	Doublespotted queenfish	**	L
	S. tol	Needlescaled queenfish	**	D, L
	Trachinotus africanus?	Southern pompano	*	N
	T. baillonii?	Smallspot pompano	***	D, N
	T. botla/russellii	Largespot pompano	***	D, N
CARCHARHINIDAE	*Carcharhinus limbatus*	Blacktip shark	*	N
	Galeocerdo cuvieri	Tiger shark	*	N
	Rhizoprionodon acutus?	Milk shark	*	N
CHAETODONTIDAE	*Chaetodon auriga*	Threadfin butterflyfish	***	D
	C. decussatus	Sri Lanka butterflyfish	**	D
	C. kleini	Whitespot butterflyfish	*	D
	C. lineolatus?	Lined butterflyfish	*	D
CHIROCENTRIDAE	*Chirocentrus dorab*	Wolf herring	***	L
CIRRHITIDAE	*Cirrhitichthys calliurus*	Oman hawkfish	**	D
DASYATIDAE	*Dasyatis kuhlii*	Bluespotted stingray	*	D
	Taeniura melanospilos/meyeni?	Round ribbontailray	*	D, N
DIODONTIDAE	*Diodon hystrix*	Spotted porcupinefish	*	D
EPHIPPIDAE	*Drepane punctata*	Concertina fish	***	D, N
	Tripterodon orbis	Spade fish	**	D
GRAMMISTIDAE	*Grammistes sexlineatus*	Sixstriped soapfish	**	D
HOLOCENTRIDAE	*Myripristis xanthacrus?*	Yellowtip soldierfish	*	D
HAEMULIDAE	*Pomadasys furcatum*	Grey grunter	**	D, L
	P. kakhaan?	Javelin grunter	*	D
	P. olivaceum	Olive grunter	**	D
	Plectorhychus flavomaculatus	Lemon fish	**	D
	P. playfairi	Whitebarred rubberlip	*	D
	P. schotaf	Minstrel sweetlips	***	D, L
KYPHOSIDAE	*Kyphosus vaigensis?*	Brassy chub	*	D
LABRIDAE	*Bodianus macrognathos*	Oman hogfish	*	D
	Coris gaimard africana?	African coris	*	D
	Labroides dimidiatus	Cleaner wrasse	***	D
	Thalassasoma purpureum	Surge wrasse	**	D
LEIOGNATHIDAE	*Leiognathus daura?*	Goldstripe ponyfish	***	D
LETHRINIDAE	*Lethrinus nebulosus*	Blue emperor	*	L
LOBOTIDAE	*Lobotes surinamensis*	Triplefin	*	N
LUTJANIDAE	*Lutjanus caeuleolineatus*	Blueline snapper	*	D
	L. fulvus	Blacktail snapper	***	D
	L. gibbus	Humpback snapper	*	D
	L. monostigma?	Onespot snapper	*	D
	L. russelli	Russell's snapper	**	D
	L. sebae	Emperor snapper	*	L

Appendix 2 continued

FAMILY	SPECIES	COMMON NAME	ABUNDANCE	METHOD
MOBULIDAE	*Mobula diabolus*	Devil ray	*	N
MUGILIDAE	*Mugilid spp.?*	Mullet	**	D
MULLIDAE	*Parupeneus macronema?*	Band-dot goatfish	*	D
MURAENIDAE	*Gymnothorax javanicus?*	Giant moray	*	D
	G. flavimarginatus?	Yellowmargin moray	*	D
	G. undulatus	Leopard moray	***	D, L
MYLIOBATIDAE	*Rhinoptera javanica*	Javanese cownose ray	**	N
PEMPHERIDAE	*Pempheris adusta?*	Dusky sweeper	*	D
PLOTOSIDAE	*Plotosus limbatus?*	Darkfin eel catfish	*	D
POMACANTHIDAE	*Centropyge multispinis*	Brown dwarf-angel	*	D
	Pomacanthus maculosus	Yellowbar angelfish	*	D
	P. semicirculatus	Semicircle angelfish	*	D
POMACENTRIDAE	*Abudefduf notatus*	Yellowtail sergeant	***	D
	A. sordidus	Spot damsel	*	D
	A. vagiensis	Sergeant major	**	D
	Chromis viridus?	Bluegreen puller	*	D
	Dascyllus trimaculatus	Domino	*	D
	Pomacentrus caeruleus	Blue Pete	*	D
POMATOMIDAE	*Pomatomus saltatrix*	Shad	**	L, N
PSEUDOCHROMIDAE	*Chlidichthys inornatus*	Yellow rockbasslet	*	D
	Pseudochromis melas?	Dark rockbasslet	*	D
RHINOBATIDAE	*Rhinobatus granulatus*	Granulated guitarfish	**	N
SCIAENIDAE	*Argyrosomus japonicus?*	Dusky kob	*	D, N
	Otolithes ruber	Snapper kob	**	N
	Umbrina rhonchus?	Slender baardman	*	D
SCOMBRIDAE	*Scomberomorus commerson*	King mackerel	**	D, L
	Thunnus albacares	Yellowfin tuna	*	L
SCORPAENIDAE	*Pterois miles*	Devil firefish	*	D
SERRANIDAE	*Cephalopholis sonnerati*	Tomato rockcod	*	L
	Dinoperca petersi	Cave bass	*	D
	Epinephalus chlorostigma?	Brownspotted rockcod	*	D
	E. polylepis?	Smallscaled grouper	**	L
	E. stoliczkae	Epaulet grouper	***	D, S
	E. tukula	Potato bass	*	D, S
SPARIDAE	*Cheimerius nufar*	Santer	**	D, L
	Crenidens crenidens	White karanteen	***	D, N
	Diplodus sargus	Blacktail	*	D
SPHYRAENIDAE	*Sphyraena sp.?*	Barracuda	*	N
SYNODONTIDAE	*Synodus dermatogenys?*	Banded lizardfish	*	D
TETRAODONTIDAE	*Arothron meleagris*	Starry pufferfish	*	D
TERAPONIDAE	*Terapon jarbua*	Thornfish	*	L
TORPEDINIDAE	*Torpedo panthera*	Torpedo ray	*	D
ZANCLIDAE	*Zanclus canescens*	Moorish idol	*	D

Note: A question mark following the species name indicates some uncertainty in identification

Abundance

* few seen
** fairly common
*** very common

Method observed

D = Diving (SCUBA and breathhold diving, most dives were < 10m depth)
L = Line-fishing (fishing by the survey team and observed line-fishing catches)
N = Gill-netting (both lobster nets and shark nets)
S = Spearing (hand-held spears)