Status of the South Coast Lobster Fishery 2009

CENARA Project Reports on Lobsters

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Executive Summary

Lobsters are the most valuable crustacean species found in Sri Lankan coastal waters. High exploiting rate following the foreign demand, resulted depletion of the stocks. All the spiny lobster species are fully exploited and *P. polyphagus* is completely harvested from the Southern lobster fishing grounds. Several attempts have being taken to assess the south coast lobster fishery based on the fisheries dependent data. The lobster resources of the South Coast Lobster Fisheries Management Area (Tangalle to Kumana) were studied using the fisheries independent data. The results of the present fisheries survey indicated:

The numerically dominant spiny lobster was *P. hamarus* with an estimated standing stock of 349688 individuals (100.3 MT) and Total Allowable Catch of 17484 individuals or 5.0 MT.
The second dominant species *P. versicolor* recorded its standing stock as 259216 individuals (Biomass 73 MT)and TAC 12961 individuals and biomass 3.9 MT. Total allowable catch for all the species (without *P.ornatus*) 11.7 MT. *P.homarus, P.longipes* and *P. versicolor* species are heavily concentrated in the Great basses and Little basses area. Those reefs acted as nursery ground for the south coast lobsters.The target of the study is to establish the Lobster fisheries co management system to the surveyed area (Hambantota district).

Introduction

Lobsters are the highest value commercial fishery in Sri Lankan coastal marine waters. The fishery is under threat due to over fishing. Already, one species *Panulirus polyphagus* has completely disappeared from Southern and Eastern coastal waters. Moreover the recent recovery efforts after the tsunami of 2004 may be exacerbating the problem because many new boats and gear were donated to the local fishing communities. Furthermore the Southern Coastal Lobster Regulations implemented in 2000 are not being followed by lobster fishers and exporters. The last lobster fisheries dependent assessment was made in 1998. Therefore it is important to conduct fisheries surveys again to bring our knowledge of the status of the fishery and standing stock estimates up-to-date to provide timely and accurate information and advice to the Department Fisheries and Aquatic Resources (DFAR). Doing so will enable DFAR to take corrective measures if required to ensure the sustainability of this valuable resource and industry.

The lobster fishery has been identified as one of the major fisheries for small scale artisanal fishers along the southern coast of Sri Lanka. It is supporting to earn reasonable amount of foreign exchange through the fisheries exports. Over ninety five percent of the lobster catch are being exported to foreign market while rest 5 percent is consumed at the locally. Major importing countries are Japan, Hong Kong, UK, Singapore, and Korea. Lower quality lobsters (Under sized, newly moulted once, Damaged or died lobsters) are sold to the local market at cheaper prices. The average local prices of live lobsters are varies from Rs. 1000 to Rs. 4500, depending on the species, Individual weight and the condition of the lobster. Tiger lobsters (*Panulirus ornatus*) receive highest market price (Rs. 4500 per Kg) rather than the other species.

Table 1. Lobster Exports from year 2000 t0 2008

Year	Export (MT)	Value (Rs. Million)
2000	164	157
2001	198	221
2002	272	317
2003	456	164
2004	236	219
2005	183	267
2006	168	307
2007	184	352
2008	249	405

Source: MFAR, Sri Lanka

According to the initial survey carried out in the Southern part of the Island, the coast from Tangalle to Kumana (122 Km in length) area identified as the most important lobster fishing area in Sri Lanka. This area is scheduled to be declared as the Southern Coastal Lobster Fishery Co- Management area (Fig. 01). The results of the frame survey and the research carried out by Dr. Jayakody revealed that the spiny lobsters are mostly found in shallow waters less than 30m in depth.

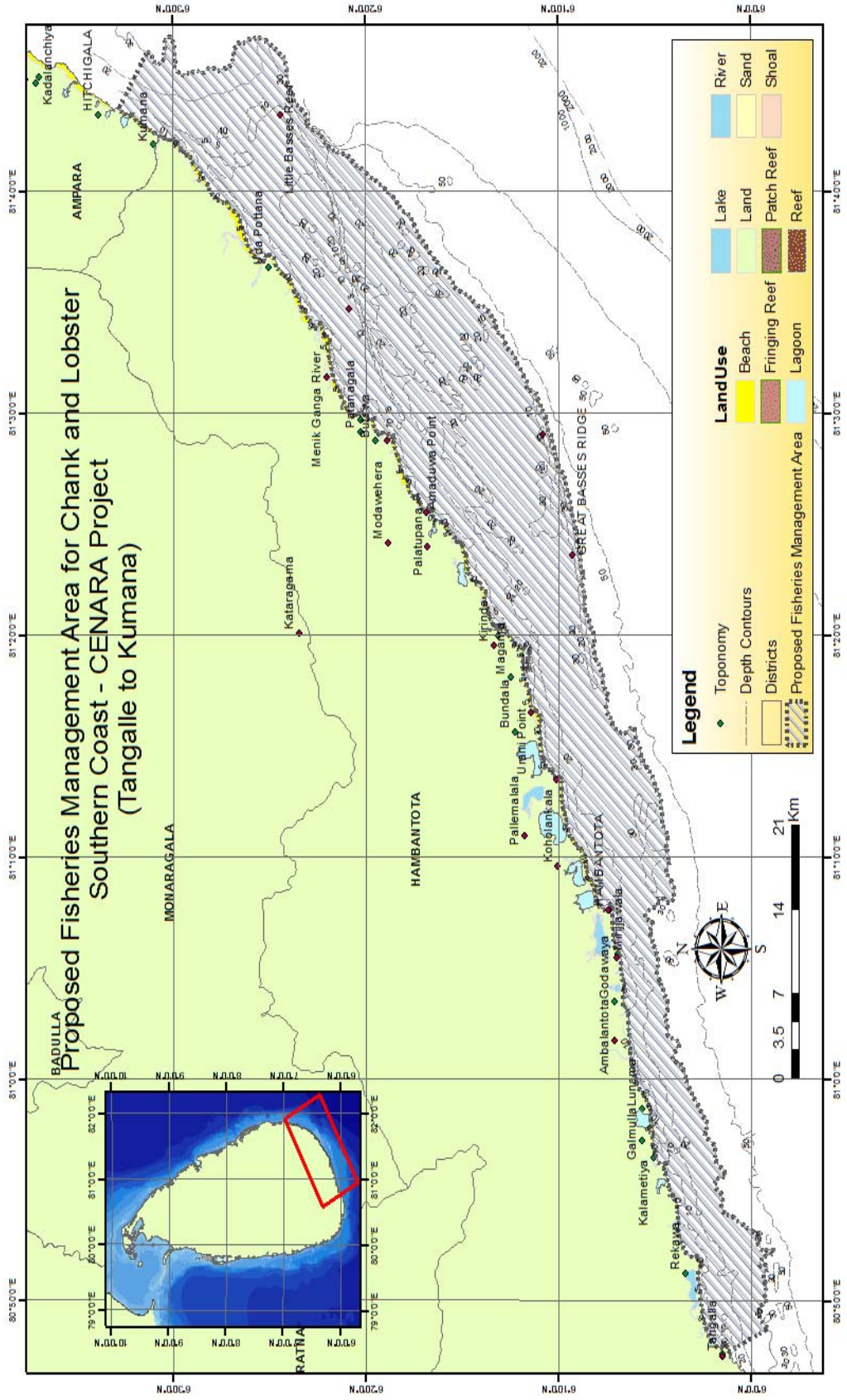

Figure 1 Proposed South coast Lobster Fisheries Management Area

Upul Liyanage NARA

Description of the Lobster Fishery

The lobster fishery along the south coast of Sri Lanka is restricted to shallow (< 30 m) near shore waters. The maximum fishing depth is determined by gear limitations (nets) and limitations of SCUBA diving.

Six species of spiny lobster occur along the 250 km stretch of coast in the South Coast Lobster Fisheries Management Unit (Jayakody & Kensler, 1986). Seagrass beds, Coral reefs, Lime stones and Sand stone are critical habitats for lobsters and serve as nursery grounds for juveniles. There was an estimated 928 km^2 of this habitat mapped (Long et al 2009).

Lobster Habitat

Rocky or coralline formations found in the sea are the best habitats (Bruin, 1960). In other words, spiny lobsters seems concentrate in regions which give the maximum cover. The species composition very with the bottom condition and the depth. *P versicolor, , P.longipes* and and *P. penicillatus* are occupied in the coral reef areas (Jayakody, 1997). Dominant species *P. homarus* occupied in several habitats such as coral reef, lime stone reef, sand stone, rock pools and crevices (Jayakody, 1997). Ecosystem degradation due to the destructive fishing gears such as Bottom set nets laying on reef area, is a major problem for the production. Distribution of the lobsters along the coast line is depends on the bottom condition, slope, salinity, turbidity and depth. Lobster Fishery is limited to some areas. In Hambantota district, from Kudawella to Patanangala contribute to the reasonable lobster production (Fig. 2). Kirinda, Amaduwa, and Patanangala (in Yala National park) are identified as the major lobster landing sites in Sri Lanka. Present lobster production in the North and Eastern part of the island is very little.

Fishing Season

Fishing lobsters is done throughout the year in the SCFMU except in February, September and Octomber when the fishery is closed. The lobster fishing season starts in August and extends to March. Over 80% of the fishermen are fully engaged in lobster fishing during this period. During the closed season many of the lobster fishermen with Fiberglass Reinforced Polyurethane (FRP) boats switch to fishing Tuna using long lines. They may also fish for tuna during the lobster fishing season because the returns are more reliable than lobster fishing and profits are higher. During the calm season which extends from October to early April the divers (migratory and resident) will also fish chanks, lobsters and sea cucumbers from Kirinda to Kumana Lobster fishing using canoes and traditional methods are highly vulnerable to bad weather and rough seas. Consequently fishing lobsters using traditional methods is restricted to the calm season.

Lobster catches vary with the lunar cycle. During full moon catches are less because lobsters can see and avoid the nets and during the rough seas lobsters come out of their crevices (personal communication).

The majority of lobster fishermen set their nets in the evening, go home and come back the following morning to collect their catch; a smaller number fish throughout the day and night. Most of the south coast lobstermen are Buddhist and do not fish during the Poya days.

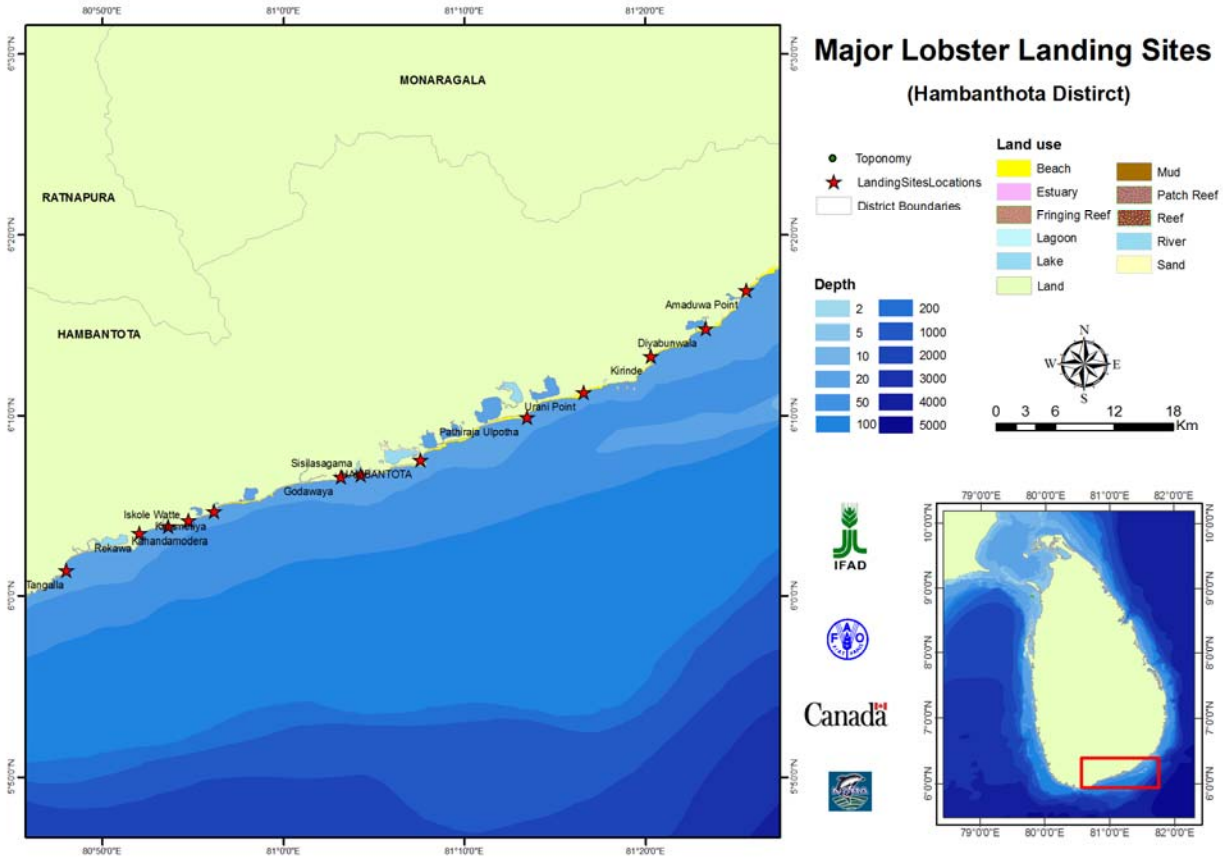

Figure 2 Major lobster landing sites of the Hambantota District

Spiny Lobster species in Sri Lanka

Spiny lobsters of the family Palinuridae are found in parts of Asia such as Sri Lanka, India, Japan, Indonesia and Malaysia. De Bruin (1962) and Jayakody (1997) identified six spiny lobster species in Sri Lankan coastal waters (Table 2).

Table 2. Scientific and common names of Sri Lankan species of spiny lobster

Scientific name used by De Bruin (1962)	Current scientific name	English name
Panulirus penicillatus	*Panulirus penicillatus*	Prong horn or variegated spiny lobster
Panulirns versicolor	*Panulirus versicolor*	Painted spiny lobster
Panulirus dasypus	*Panulirus homarus*	Scalloped spiny lobster
Panulirus ornatus	*Panulirus ornatus*	Ornate spiny lobster
Panulirus japonicus	*Panulirus lonqipes*	Japanese spiny lobster
Panulirus polyphagus	*Panulirus polyphagus*	Mud spiny lobster

Painted spiny lobster *Panulirus versicolor*

Two pair of conical spines are present on the antennular somite, the anterior pair being twice the size of the posterior pair. The rest of the somite is unarmed. The flagella of the first antenna are white in color. The post orbital spines are large and interiorly curved. The cephalathorax is divided into an anterior spiny region and a posterior less spiny region. Waxy white lines are present along the eyes, the post orbital spines and along the cephalathoracic carapace. The base of the dark bluish black. Each walking leg is bright bluish green in color with striking white lines running along its length. The abdomen is not grooved in adults but in small specimens rudimentary groves are present. Each abdominal somite has a dark blue, almost black hard running across the somite. A lateral abdominal spine is present on all six segments. In addition, there is a cluster of four spines on the lateral boarder of the third, fourth and fifth abdominal somites. The pleopodes are bluish green with different white lines running in the middle. The base of the teleson, which is calcareous has symmetrical wavy white lines forming a white triangle on each side. The third maxillipede has no expode. The second maxillipede has a single join of pagellum.

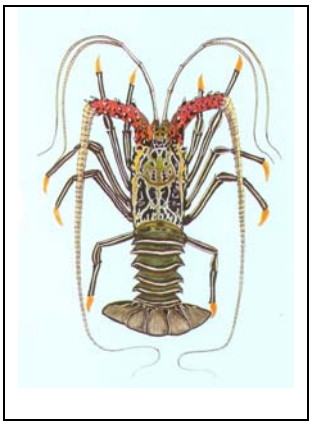

Figure 3. Painted Spiny Lobster *Panulirus versicolor* (Adopted from Spiny lobsters of the Indian ocean occurring around Sri Lanka)

Variegated spiny Lobster Panulirus penicillatus

The antennular somite is armed with a pair of large anterior spines and a pair of small posterior spines. The small are fused to the base of the larger spines. A blue patch, semi circular in shape, is prominent at the base of the second antenna. This spreads from the lateral border of the antennular somite to the lateral border of the basal joints of the second antenna. The cephalotharax is divided into a anterior spiny region and a posterior, relatively unarmed region, bearing numerous nodules. The tips of all spines in the anterior region of the carapace and the second antenna are brown in color, the bases being yellow.

The walking legs are dark olive green in color with pale yellow strips running along their length. The abdomen somites are transversely grooved, the groves being uninterrupted on all six somites. The abdomen is smooth its lateral borders produced into long backwardly directed spines one corresponding to each somite. Furthermore, a small tooth is present between two somites on all but the first and sixth abdominal somites. The pleopodes are dark olive green color with white lines running along their margins. The third maxillipede has a single jointed exopod without a flagellum. The second maxillipede has an exopod with a many jointed flagellum.

Figure 4. Variegated spiny lobster *Panulirus penicillatus* (Adopted from Spiny lobsters of the Indian ocean occurring around Sri Lanka)

Scalloped spiny Lobster Panulirus homarus

Panulirus hamarus abundant on the west, southwest and south coasts of Sri Lanka (Bruin 1995). These species is nocturnal and highly gregarious and also making groups with all stages, males and females. Contribute to the 90% of the lobster production.

The antennular somite has four principal spines, the anterior pair being only slightly larger then the posterior pair (Figure x). In the centre of these four principle spines a group of spinules is present.The first antenna is olive green in color, there being white patches at the articulations of the segments. The flagella of the first antennae are also olive green in colour, with white bands along their lengths. The cephalathorax is divided into an anterior region bearing many forewardly directed spines and a few tubercles and a posterior region with few spines but many tubercles. Tiny yellowish white spots are found distributed throughout the carapace. The walking legs are olive green in color, with numerous small yellowish white patches. The abdomen is olive green in color dotted with

numerous small yellowish white spots. These spots are small on segment one, two and three but conspicuously larger on segment four, five and six. A conspicuous white patch is found on the antero-lateral region of each abdominal somite. Each somite is produced laterally into a backwardly directed spine while a cluster of four spines is present laterally of somites two to five as in *P. versicolor*. The abdominal somites are grooved transversely but the interruption of these groves medially is a very variable feature.

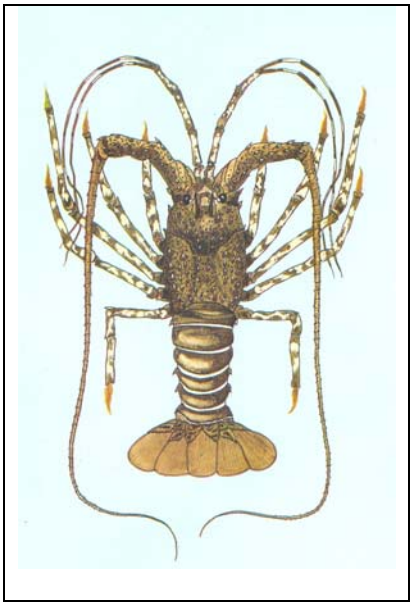

Figure 5. Scalloped spiny Lobster *Panulirus homarus* (Adopted from Spiny lobsters of the Indian ocean occurring around Sri Lanka)

Ornate spiny lobster, Panulirus ornatus, *Divi Issa*

Ornate spiny lobster is the largest and the most demanded spiny lobster species found in Sri Lanka. The much more abundance can be observed in the east, northwest and north regions rather than the south coast (Bruin 1995).

The antennular somite has four principal spines but the posterior pair is very much smaller than the anterior pair (Figure x). Small cattered spinules are present on the antennular somite. Both the anterior and posterior regions of the cephalotharax have numerous spines in young specimens. In older specimens the number of spines on the posterior regions of the caraphase is considerably reduces. The spines are orange at the base and light green at the tip. Numerous nodules are also present on the posterior region of the carapace there being only a few on the anterior region.

The base of the second antenna and the anterior region of the carapace is vermiculate. Bright orange spots are present on the posterior region of the carapace. The walking legs of these species are decorated with alternate bands of cream and maroon. The peduncles and flagella are also similarly banded.

The antero lateral border of each abdominal segment has a distinct dark patch while a second less conspicuous mark is present medial to the first patch. Each abdominal segment is produced laterally into a backwardly directed spines and in addition a cluster of spines close to the above spines are present on segments two to five. The calcareous base

of the teleson has two white patches on either side of the medial line just behind the posterior border of the last abdominal segment. The exopod of the second maxillipede has no flagellum but only a tuft of setae.

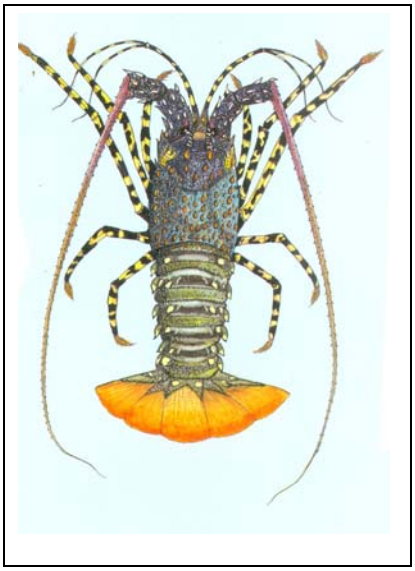

Figure 6. Ornate spiny lobster *Panulirus ornatus* (Adopted from Spiny lobsters of the Indian ocean occurring around Sri Lanka)

Japanese spiny lobster *Panulirus longipes*

The antennular somites has two principal spines, posterior to which are 4-6 ir5regularly arranged spinules. In *P. longipes* there are 4-6 tubercles anterior to the principal spines. Cephalothorax and the tail of the *P.polyphagus* is plainly reddish brown in coloration with small yellowish and or yellowish white spots on the body. The abdomen is dotted with yellow white spots, there being a large spot on the lateral border of each abdominal segment. The peduncles of both antennae have white marks, the flagella possessing white bands. The legs and third maxillippede are violaceous in ground color with yellowish white longitudinal stripes and a few white spots. A yellowish white spot is present on the base of each pleopode except that of the first and second segments. Antennular segments ha stwo principal spines, posterior to which are a few scattered spanules. Frontal edge of the antennular somite has a few tubercles. The groves on all the abdominal segments are uninterrupted in the medial line.

Figure 7. Japanese spiny Lobster *Panulirus longipes* (Adopted from Spiny lobsters of the Indian ocean occurring around Sri Lanka)

Mud spiny lobster - P. polyphagus

The antennular somite is armed with two principal spines, the rest of the somite being unarmed. The cephalothorax is divided into an anterior and a posterior region with more numerous spines. Ground color of the carapace is bluish green with a yellowish white line running parallel to the length of the body in the anterior region. A few yellowish white spots are found in the posterior region of the carapace. The walking legs are similar in color to the carapace with yellowish white patches along their length.

The flagella of the antennules are distinctly banded with white and brown. There are no groves on the abdominal segments but the segments are pitted with yellowish white spots. A discontinuous yellowish white line is found on the posterior border of the first abdominal segment. Continuous creamy white lines of greater with are found on the posterior border of the next five abdominal segments. The abdomen is bright bluish green.

Regulations for Management

In 1973 Government of Sri Lanka gazetted the lobster fisheries regulations designed to control fishing effort to ensure sustainability of the stocks. These regulations have been in force for 27 years (From 1973 to 2000). Harvesting and marketing undersized lobsters (carapace length and tail length must be above 3.15 and 4.5 inches respectively), newly moulted animals, female lobsters with external eggs, removing eggs from the tail were prohibited by these regulations. A licensing system was introduced for fishermen engaged in the lobster fishery as well as exporters and locals involved in marketing and processing lobsters.

As a result of poor lobster catches in the late 1980's NARA conducted a stock assessment survey which showed that the abundance for all species of lobster was declining (Jayakody, 1999). The majority of lobster fishers (>60 %) used Moxy nets which was damaging coral habitats. Lobster fishers brought considerable amounts of coral to the shore entangled in their nets.

Currently lobster production in the North and Eastern part of the island is very little due to the civil war condition. Before 1980 lobster fishers in the south coast fishery moved to the east coast fishery to fish for ornamental fish, lobsters and chanks during the south west monsoon season. With the onset of the north east monsoon they returned home to start fishing lobsters there again. This meant that the fishing grounds were fallow for six months a year acting as nursery grounds. Now lobsters are fished in the same fishing ground throughout the year (except February and September) which is overfishing the lobster stocks.

Considering the importance of Southern Coast Lobster fishery, based on the NARA stock assessment survey in 2000 Hon. Minister of Fisheries brought an amendment for the lobster fisheries regulations imposed in 1973. According to the amendment February and September months were declared as closed season for the Southern coastal region because of those months are the peak reproductive seasons of the year, females having external eggs and spermatozoa. The minimum legal size was also revised from 5 to 6 cm for the five lobster species (*P. homarus, P. polyphagus, P. penicillatus, P. versicolor and P. longipes*). The minimum carapace length for *P.ornatus* (Large variety) was revised from 6cm to 10 cm. Minimum legal size for the lobsters were revised considering the size disparity when they attain sexual maturity.

Species Composition

The south coast of Sri Lanka provides habitats for five spiny lobster species: *Panulirus homarus, Panulirus longipes, Panulirus ornatus, Panulirus versicolor* and *Panulirus penicillatus*. In recent times the mud spiny lobster *Panulirus polyphagus* has completely disappeared from the lobster catches (Fig 7).

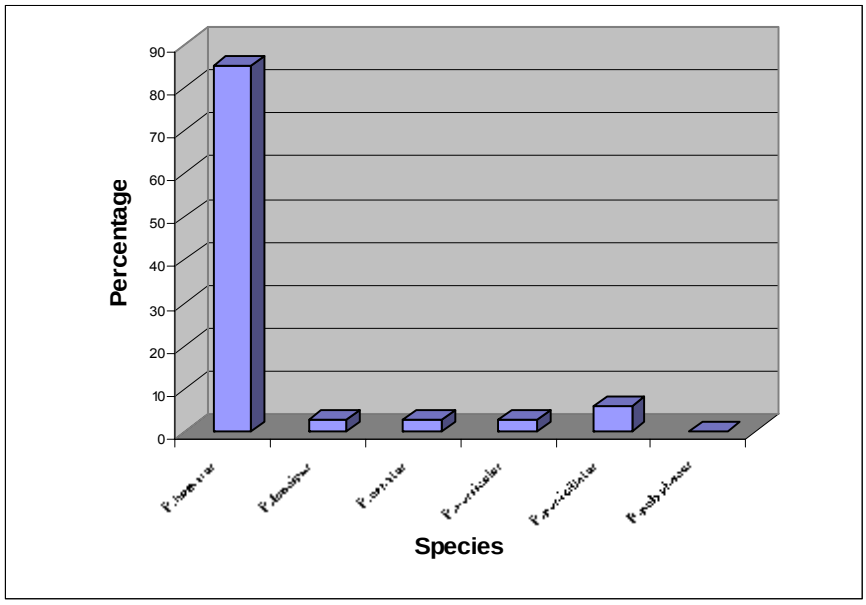

Figure 8 Species composition of the commercial catch (year 2006-7) (Liyanage 2008 Unpublished)

Table 3 Changes in the species composition of Southern coast lobster catch from 1989 t0 2007

Species	Percentage of

	the catch			
Year	1989-91	94-96	97-98	2006-07
P. homarus	74	70	83	86
P. ornatus	8	10	5	3
P.penicillatus	6	8	5	3
P.longipes	4	6	4	2
P.versicolor	6	5	3	6
P.polyphagus	2	1	0	0

(1989 to 1996 data from Jayakody,1997-2007 data from Liyanage unpublished 2008

A decade ago six species of spiny lobster were recorded in the commercial catches from the south coast fishery (Jayakody 1999). During this survey only five spiny lobster species contributed to the commercial catch.According to the table 3 *Panulirus homarus* - sand lobster is the most dominant species found contributing 70%-86% of the catch. After the introduction of the 1996 Southern Coastal Lobster Fisheries Regulations there was a trend of increasing *P. homarus* in the catch. The Indian lobster *P. polyphagus* is completely exploited and was absent from the catch from January 2006 until the present. Catches of *P. ornatus*, *P. longipes* and *P. penicillatus* have also been declining over this time as well.

Females with External eggs

Catching female lobsters with external eggs is a major cause of stock over exploitation. Lobsters breed throughout the year with two peak spawning periods per year (De Bruin 1962; Jayakody 1991) The present study revealed that among two peak spawning seasons, April and September months had a highest rate of females with eggs. Based on the spawning seasons February and September months are declared as closed season for the Southern coast lobster fishery. Present study and the De Bruin's study in 1962 revealed that the peak spawning seasons can be shift with the time. However, this closed period is limited to early two weeks of the each month and just after 15 th of the month fishermen are starting fishing. The catch is kept under the sea while over the close season and sold. Due to highest supply after the close season and the weakness due to keep in underwater cages for a long time, lobster collecting companies are paying lower price for the fishermen.

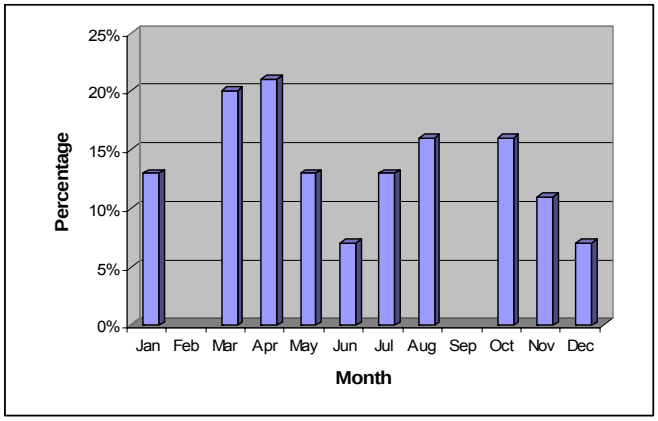

Figure 9 .Percentage of Females carrying external eggs (Liyanage 2008 unpublished)

Under sized lobsters

Minimum legal size was imposed considering the size disparity when they attain sexual maturity. Minimum length of the carapace length for the five lobster species (*P. homarus, P. polyphagus, P. penicillatus, P. versicolor and P. longipes*) are 6 cm. Minimum carapace length for the *P.ornatus* is about 10cm. The percentage of the under sized lobster represent in the catch is mentioned in the table 2.

Table 4 Percentage of the Undersized lobsters in the catch

Species	Percentage of the undersized lobsters (No. per 100 individuals in each species)
P. homarus	16
P. ornatus	7
P.penicillatus	5
P.longipes	20
P.versicolor	16
P.polyphagus	No catch

(Liyanage 2008 unpublished)

All five species of spiny lobsters are inhibit in the same fishing ground in different densities. Since over ninety percent of southern lobstermen use bottom set gill net in 3 ½ to 7 inches in mesh size for the fishery, all species are and sizes are entangled in the nets without considering the selection. As a result of the small meshed nets both larger once in the small varieties and the smaller once in the larger species are also entangled in the same net. Percentage of the undersize lobsters in the catch are shown in the fig 3. Following the North East monsoonal period, it is observed that the seasonal oscillation of the undersize lobsters representing the catch from October to January and this period identified as the Southern coast lobster season.

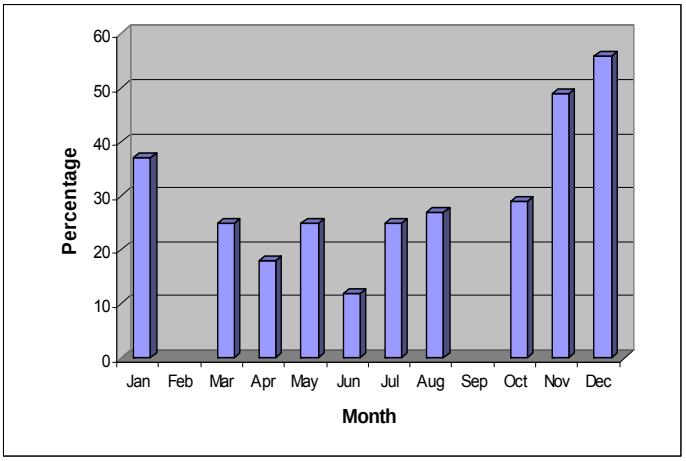

Figure 10 Percentage of undersize lobsters represent in the catch (Liyanage 2008, unpublished)

This study revealed that the lobster catches in December consisted of more undersize lobsters than the legal size and it is indicated that in the future, number of small lobsters entering into the fishery will be reduced drastically if not immediate action taken to control the illegal fishery.

Fishing license

According to the Fisheries and Aquatic resources act, No 2 Of 1996 every person who involve in Southern coast lobster fishery must be take a license for the fishing. According to the present study, there are about 300 fishermen engage in lobster fishery in Hambantota district and about 10 % of them only have valid license. Ninety percent of the lobster fishermen are engage in illegal fishery. This condition is common for the other district also. The divers engage in the chank fishery in Kirinda and Amaduwa area are involved in lobster fishery during the night time. Divers are specially targeted the large size Tiger lobsters occurring in the reefs off Kirinda

Changes in the Catch per Unit effort

Thee types of craft including FRP boats with 15 or 25 Hp engines, traditional canoes and motorized traditional craft with 8 or 15 Hp engine are used to lobster fishing in the Southern coastal region. Crew size of the OBFRP, MTRC and the NMTRC are respectively three, two and one.

Table 5 Changes in the Catch per Unit effort

Year	CPUE (Kg/Craft/Day)
1992	3.13
1998/1999	1.38
2001	2.23
2006/2007	1.52

The CPUE in 1998/99 period is less than the 1992. But after implementation of the new regulations in year 2000 again it start to increasing. As a result of the more craft engage in the fishery after Tsunami present catch rates are declining.

Lobsters are fished on the South Coast, North West and East Coast. Because of the LTTE conflict there is no information on the north coast. Although landing data has been collected for all these fisheries for the last decade there have been no fisheries independent surveys of spiny lobsters in Sri Lankan waters.

The purpose of the study is to:

- Describe the South Coast Fisheries Management Unit (SCFMU) study area (Appendix 1) and lobster fishery;
- Sample the spiny lobsters in the SCFMU to obtain fisheries independent estimates of standing stock (abundance and biomass); and
- Make recommendations for management of this resource.

Materials and Methods

Preliminary survey

Required primary information for establishment of the South Coast Lobster Management unit were collected using the pretested questionnaire. The lobstermen of the Hambantota district from Tangalle to Kirinda interviewed by the trained NARA staff during the 2008. The lobstermen were interviewed at their landing sites as well as their houses. The information on fishing craft, gear, fishing time, fishing seasons, migration pattern, depth were collected. Collected information tabulated on Microsoft Excel worksheet.

Survey Design

Lobsters inhibit rocky or coralline areas which protects them from predators. These rocky and coralline lobster habitat areas are highly variable both in terms of area (patch size) and spatial arrangement of patches. Except for fringing reef – which can be mapped using satellite imagery - it is not possible to map submerged lobster habitat using satellite imagery. Most of the offshore shallow water (< 30 m) areas of Sri Lanka have not been mapped to the resolution required to identify lobster habitat. The challenge of providing reliable estimates of standing stock centers around resolution and accuracy of mapping lobster habitat. Consequently it was necessary to map bathymetry in the study area. The methods used for this are described in detail in (Long et al 2009).

Briefly: the seabed for 130 km of coast out to 30 m water depth was mapped for bathymetry using a Garmin echo sounder. Over 5,000 km of seabed was tracked with depths recorded every 3 seconds. From this data the bathymetry was modeled using Map source, Ozi Explorer, 3D Analyst and Spatial analyst Extensions of Arc GIS 9.3 (ESRI) software. From this map it was possible to digitize the raised coral / limestone platforms in the study area (918 km^2) – areas potentially suitable as lobster habitat. From this map we had two strata: (1) Potential lobster habitat (43 km^2); and (2) marginal lobster habitat (875 km^2).

(A) (B)

Figure 11. A& B. Tracking with GPS and echo sounder for bathymetry seabed mapping

GIS was used to generate 146 sites randomly distributed within the strata labeled potential lobster habitat strata and 69 sites within the strata labeled as marginal lobster habitat.

The strata statistics indicate that 95% of the area was mapped as marginal lobster habitat (Table 6). It was important to sample these areas because even if there was a very low average abundance of lobster the total could be quite substantial because the area is so large

Table 6. Strata statistics: W_h: Stratum *h* weight (N_h/N); Transect length = 100 m; Transect width = 2 m. Study area size = 918 km^2; N = 215 sites; N_h: number of sites sampled in strata *h*; N = 9.1812E+08; n = 215; f_h: sampling fraction for stratum h.

Stratum	W_h	n_h	f_h	Strata area km^2	N_h
Marginal lobster habitat	0.9528	69	0.321	875.4	875
Potential lobster habitat	0.0464	146	0.679	42.7	43

Field Sampling

The Belt Transect method using 100 m x 2 m transects was used to sample lobsters. Before starting the survey, divers were trained how to sample belt transects, identify lobsters and record substratum type, current, water depth and horizontal water visibility.

The boat operators were also trained to use GPS to navigate to sample sites as accurately as possible.

The data collected at each site included but was not limited to diving time, water depth, lobster species, counts, substrate type, water current, visibility and wind condition (Appendix 4 - Data sheet). The weight of each lobster was estimated by the commercial divers who were experienced in this practice.

In addition to sampling belt transects 25 lobster traps were set at selected locations by lobster fishers. This was done to assess whether the nets were selectively fishing lobsters and as a check that belt transects were sampling all lobsters.

The trap was made of a 0.5 m diameter steel ring with 3 inch mesh nylon eight fly net. Concrete blocks weighing 2 kg were placed in the middle of the trap to anchor it securely to the seabed and baited with seasoned Tilapia. A buoy was attached to the trap to assist in its recovery. Traps were set in the morning and retrieved the following morning.

(a) (b)

Figure 12. (a) and (b). Settings the traps

Field data was entered into an Excel workbook after each days sampling. The Excel Data Entry workbook was set up for the CENARA project and included extensive validation for quality control (CENARA Data Systems SOP 2009).

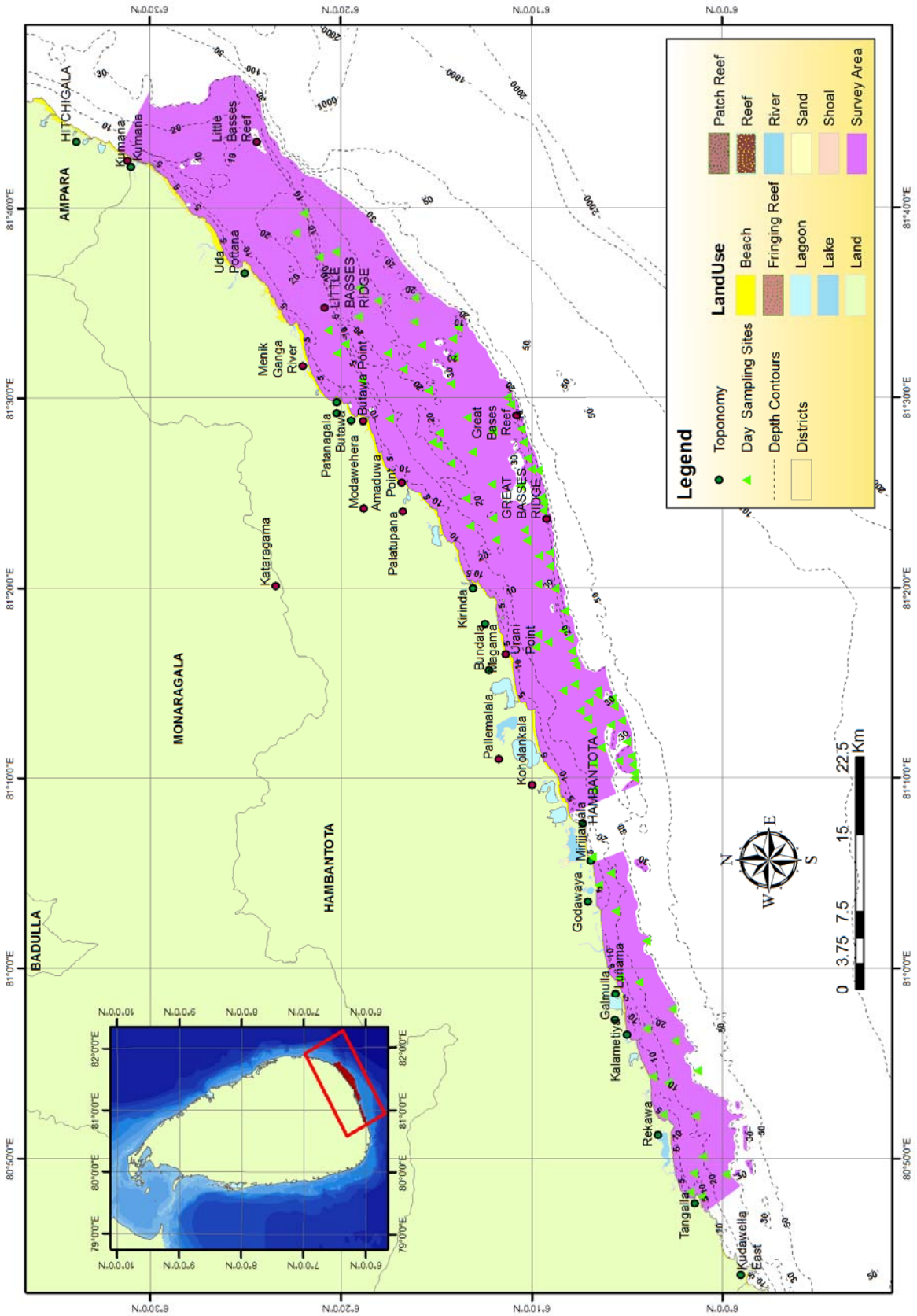

Figure 13. Map of the sampling sites of potential lobster habitats.

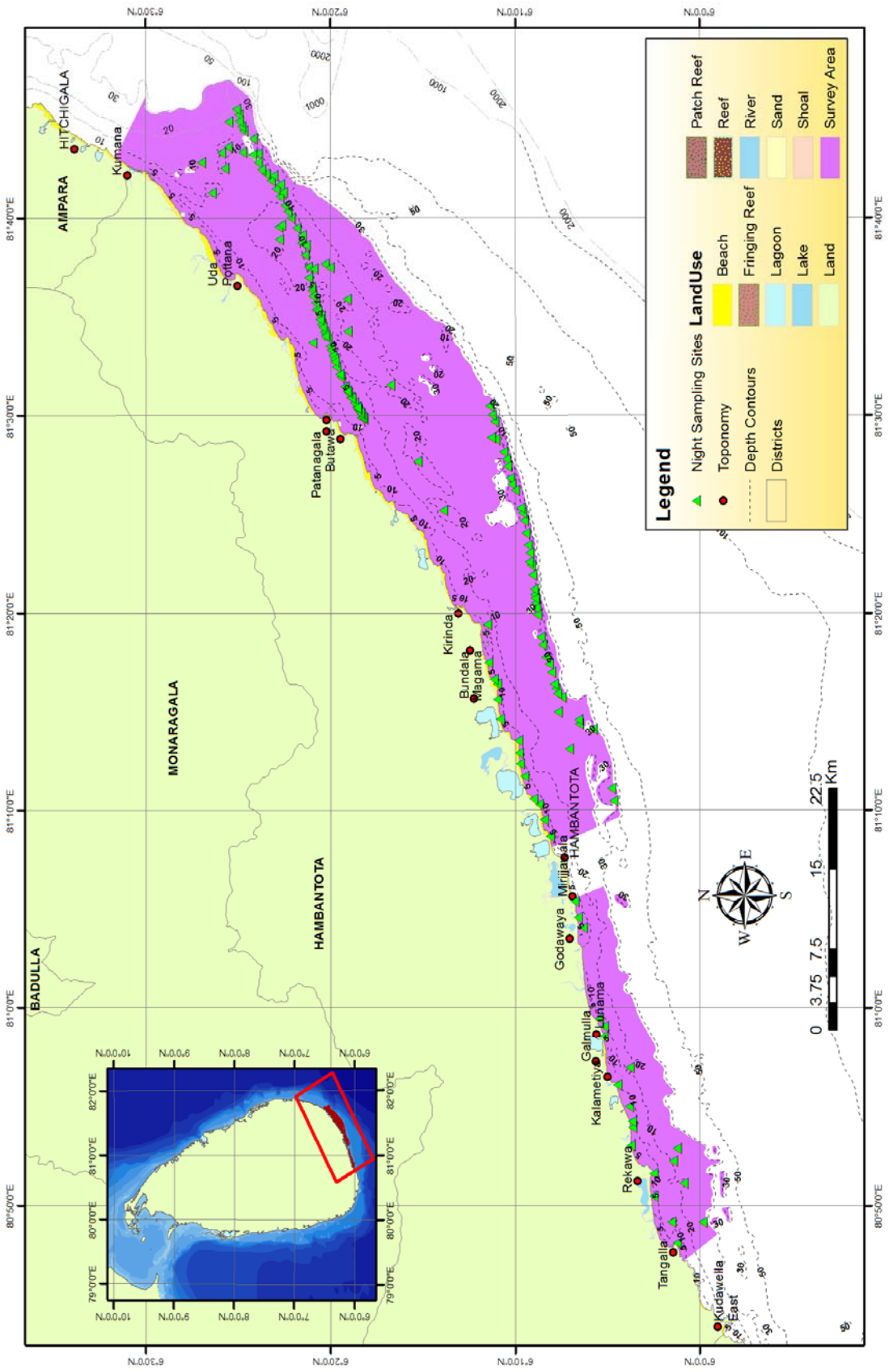

Figure 14. Map of sampling sites of lobster habitats.

Data

Analysis

The CENARA Data Systems Standard Operating Procedure (SOP) included MS Access queries to join the various worksheets in the Excel Data Entry workbook and to export the data for input into SPSS scripts where standing stock calculations were performed (CENARA Data Operations SOP 2009).

The SPSS scripts used formulae shown in Appendix 2.

The output from SPSS was entered into an Excel workbook for final formatting before being copied and pasted into this report.

Calculating Maximum Sustainable yield and Total Allowable Catch

The main objective of the fisheries stock management is to prevent recruitment overfishing. In other word breeding stock is not reduced by fishing to a level where recruitment to the fishery is drastically reduced. The maximum sustainable yield (MSY) of a fishery is reached when fishing effort is such that, in equilibrium, the products of recruitment and growth over mortality (the surplus yield) is at a maximum. The calculation of MSY requires information on the stock-recruitment relationship of the fished population. When there is little data to formulate a stock-recruitment relationship, indicative MSY can be calculated with the theoretical rule-of-thumb model MSY = ½ MB_0 (Gulland 1983), where M is natural mortality and B_0 is the virgin biomass. The model is based on the assumption that at least half the unfished breeding population (the virgin biomass) is needed to maximize surplus yield, and that any value below this leads to over exploitation (Gulland 1983; Hilborn and Walters 1992). It has being found that the all the lobster species are overexploited (Jayakody 1999). Considering the importance of conservation the stocks lower 90% confidence interval of the standing stock were used to calculate the MSY.

Since the lobsters are fully exploited considering the conservation matters TAC calculated as
TAC= ½ MSY

Results

Result of the preliminary survey

Hambantota district is contributed to the over 60 percent of the lobster production of the country. Before starting the underwater visual survey of this project it was carried out a frame survey to understand the present status of the lobster industry in the district and to collect basic information required for designing the project. During the initial survey period it was identified 14 important lobster landing sites in the district (Fig 2.). Those centers are mentioned below from west to east of the study area (Table 7).

Table 7 Important lobster landing sites in the study area

Fisheries Inspector Division	Landing Site
Tangalle	Tangalle
Rekawa	Rekawa oru wella
Kahandamodera	Kahandamodera oruwella Iskole wella
Kalametiya	Kalametiya Harbour
Godawaya	Godawaya, Sisilasagama
Hambantota East	Hambantota Harbour
Kirinda	Uraniya, Pathiraja, Kirinda, Diyabunwala Amaduwa,

Kirinda Fisheries Inspector Division in the Eastern part of the Hambantota district was identified as the most important lobster landing area in the country. Big amount of lobster fishermen are fishing in the sea adjacent to the Yala and Bundala National parks owing to Kirinda FI division. Three major migratory lobster landing sites were identified (Amaduwa, Diyabunwala and Uraniya) in the coast of these parks. During the lobster season peoples from Rekawa, Kahandamodera Mawella and Kudawella are migrated to these sites.

According to the frame survey 622 numbers of lobstermen were identified from the district. But only 101 lobstermen have being taken license from the Fisheries Department, Tangalle.

Table 8 Fisheries Inspector division vise Craft and lobster fishing population

Fisheries Inspector Division	Number of craft	Lobster fishes
Kirinda	51	170
Hambantota	30	75
Sisilasagama	38	88
Kalametiya	16	37
Kahandamodera	21	69
Rekawa	38	104
Tangalle	29	79
Total	223	622

While consider the lobster fishing population of the study area over 2/3 of the fishermen are fishing in the Kirinda Fisheries Inspector division including both residential and migrants. Among the 104 lobstermen in the Rekawa FI division are fishing in both Rekawa and Kirinda, Amaduwa or Diyabunwala

Craft & Engine capacity

Three craft types were identified in the study area with the numbers Fiber Reign Forced boats (FRP)157, Motorized Traditional Boats (MTRB) 5 and the Non Motorized Traditional Boats (NTRB) 86.

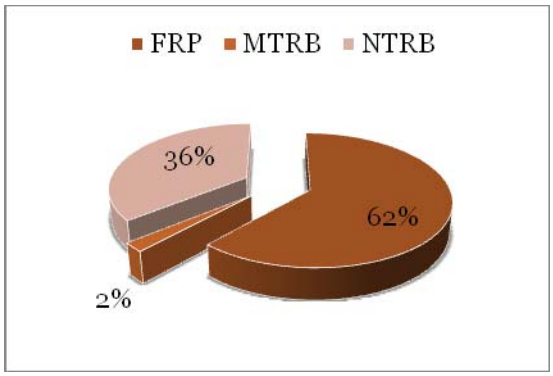

Figure 15 Percentages of the different craft types used in the lobster fishery

From its sixty two percent of the lobstermen are using Fiber Rein Forced boats for the lobster fishing operations. The number of Non Motorized Traditional paddling outrigger canoes are comparatively lower than the other craft types, because:

- FRP & MTRB boats can be use under rough weather conditions.
- Enough space for more gear units.
- Can be fishing far away from the landing site.
- Less risk and easy to maintain.
- Received more boats as Tsunami grants.

A

B

Figure 16. A&B Different craft types used in the lobster fishery

E

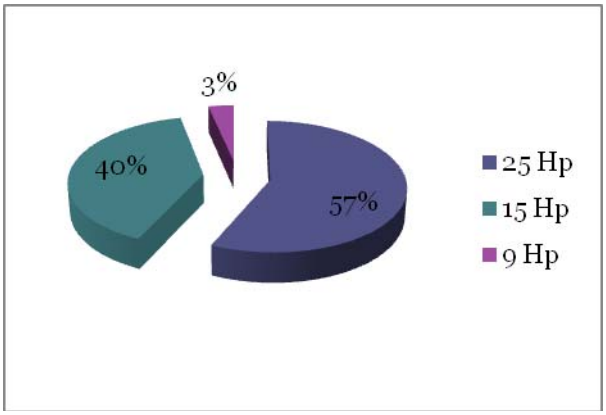

Figure 17 Engine capacity of the crafts

According to the Fig.17. Fifty seven percent of the lobstermen in the study area are using 25 hp outboard motor engines with FRP boats length 6-7 m while other 40 percent are using 15 hp engines with FRP or MTRC. These boat engines can be use for the lobster fishery as well as the tuna long line and other one day fishing operations. Almost all the 9 Hp engines are running with the Motorized Traditional Canoes.

Other than this three craft types some people are using air filled vehicle tubes for setting the lobster nets. This method is too risky and also not a recommended method for fishing.

The average number of crew per craft is as follows (Table. 9.)

Table 9 The crew number per craft

Craft Type	Crew
FRP Boats	2-4
MTRB	2-3
NTRB	1-2

Fishing Gears

Ninety five percent of the lobstermen in the study area are using 9 fly nylon 4 1/2 inches meshed bottom set gill nets for fishery. The selection factor of the net is invalid for the lobsters since the lobster are entangling in the nets. However 3 ½ to 4 ½ meshed gill nets are using for the small size lobsters (P. *homarus*, *versicolor*, *longipes* and *penicillatus*) and the 7 inches meshed nets (Divi Dela) are used t0 catch *P.ornatus*. During the calm season most probably lobster divers are operating in Kirinda to Kumana area. Lobster net operators are against with the lobster, chank and sea cucumber collectors since they collect more lobsters during the operation period. However, primitive fishing gears such as Lobster traps are also practicing in the near shore shallow waters with the traditional crafts.

Migration Pattern

As mentioned earlier Two distinctive fishing seasons can be observed following the Southwest and Northeast

monsoonal periods. The southwest monsoonal period start from May and it ends in August. Most of the small craft operated fishermen (FRP, NMTC, MTC) loss their jabs during the season due to rough sea which is accelerated by the South west monsoonal winds. The migratory lobstermen living in the Rekawa, Kahandamodera, Kudawella and Mawella are migrated to their temporary landing sites in Amaduwa, Patanangala, Kirinda, Diyabunwala located in the eastern part of the district during the lobster season and again shifted to their permanent places during the offseason.

Figure 18. Migratory lobster fishermen from Rekawa, mending damaged nets at the Amaduwa landing site.

Marketing

Two big lobster exporting and processing companies (Srimic & Alpex) are established their branches in the district. In Kirinda there are about 6 lobster collector including the two exporting companies are located. Other than this two companies there are many landing site level collectors throughout the district. All the lobster are purchased in live form and temporally stocked in the aerated cement tanks until transporting to the Colombo. The damaged and died lobsters are purchasing at the cheapest prices. The companies are providing fuel, foods, water, fishing gears etc for the migratory lobster landing sites daily while collecting the catch.

Figure 19. Lobster storage tank system at the Kirinda Lobster collecting centre

Result of the Stock estimation

Traps

Scalloped spiny lobsters –*P. homarus* are inhibits in the shallow coastal waters close to the beach. The results of the under water visual survey is not much accurate in the shallow turbid waters due to the less water visibility. At the same time underwater survey cannot be applied for the Tiger lobster- *Panulirus ornatus* since they are living in below 30 m in depth. The commercial divers dive above the 30 m in depth. To improve the accuracy of the survey, 25 numbers of traps were set at the shallower turbid areas to asses the *P.hamarus* stock. The trial was abandoned due to its inefficiency during the season.

Standing Stock Estimates

There was an estimated 234929 spiny lobsters from the South Coast Lobster Fisheries Management Unit (SCLFMU) (Table 10).

Abundance

Table 10. Spiny lobster standing stock estimates. Abundance: Maximum Sustainable Yield and Total Allowable Catch:

Species	Abundance	*MSY*	TAC
Panulirus homarus	349688	34968	17484
Panulirus longipes	11065	1106	553
Panulirus ornatus	-	-	-
Panulirus penicillatus	40262	4026	2013
Panulirus polyphagus	0	0	0
Panulirus versicolor	191607	19160	9580
Total	692171	69217	29630

According to the result showed in the Table 10 numerically dominant species *P. hamarus* is the most abundant spiny lobster species in the South Coast Lobster Management Area. The Abundance, Maximum Sustainable Yield and the Total Allowable Catch of the species are respectively 349688, 34968 and 17484. The second highest Abundance and MSY were recorded by *P. versicolor* as 191607, 19160 individuals and its TAC as 9580. *P. longipes*, the third most abundant species recorded its Abundance, MSY and TAC values as 11065, 1106 and 553 individuals. *Panulirus polyphagus* and the *P. ornatus* were not represent in the survey area because of *P. polyphagus* was completely harvested from the southern fishing grounds and the area where is *P. ornatus* inhibits in the depth below 30 m was not surveyed due to the physical barriers.

Lobster abundance and distribution are maximum in the areas of the Great basses and the little basses ridges and Great basses and little basses reefs adjacent to the Yala national park in the eastern part of the management area (Fig 20-26). At the same time highest *P.homarus* abundance recorded (Figure 20) in the Tangalle. *P.homarus* abundance in the great basses and little basses are varies 150-350 individuals /m^2. About 350-500 *P. versicolor* individuals per m^2 were recorded in the above mentioned ridges and the ridge line parallel to the land in the off Hambantota. When consider the abundance of the *P. versicolor* the species inhibit in the ridges far from the coast (Fig 21)and the *P.hamarus* are inhibits in the reefs and rocks adjacent to the land mass (Fig 20). However, all lobster species are concentrated to the Great basses and little basses area. Following the highest abundance and biomass most of the lobster fishes and collectors are concentrated to the above area.

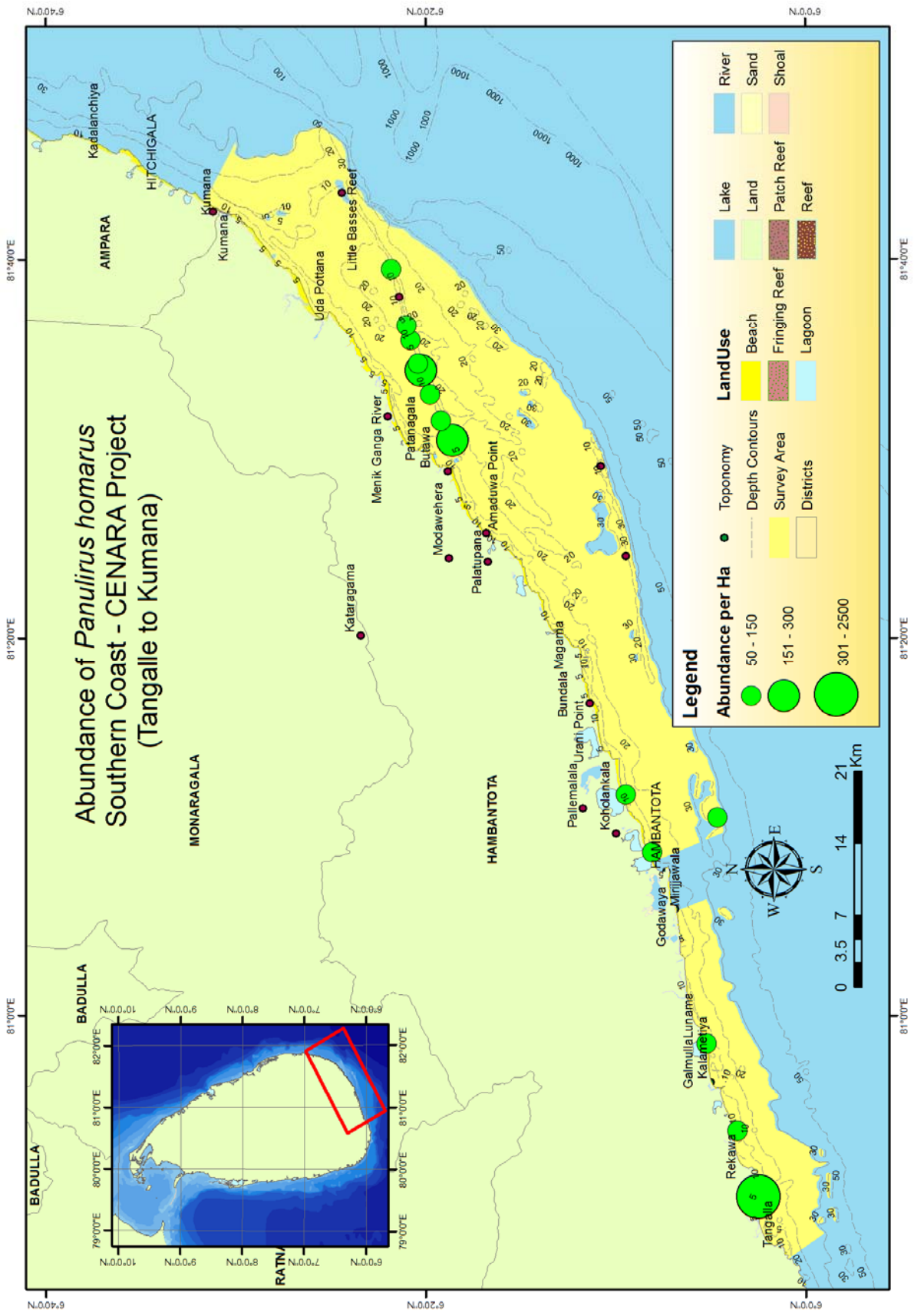

Figure 20 Distribution of the abundance of *P.homarus* in the SCLFMA

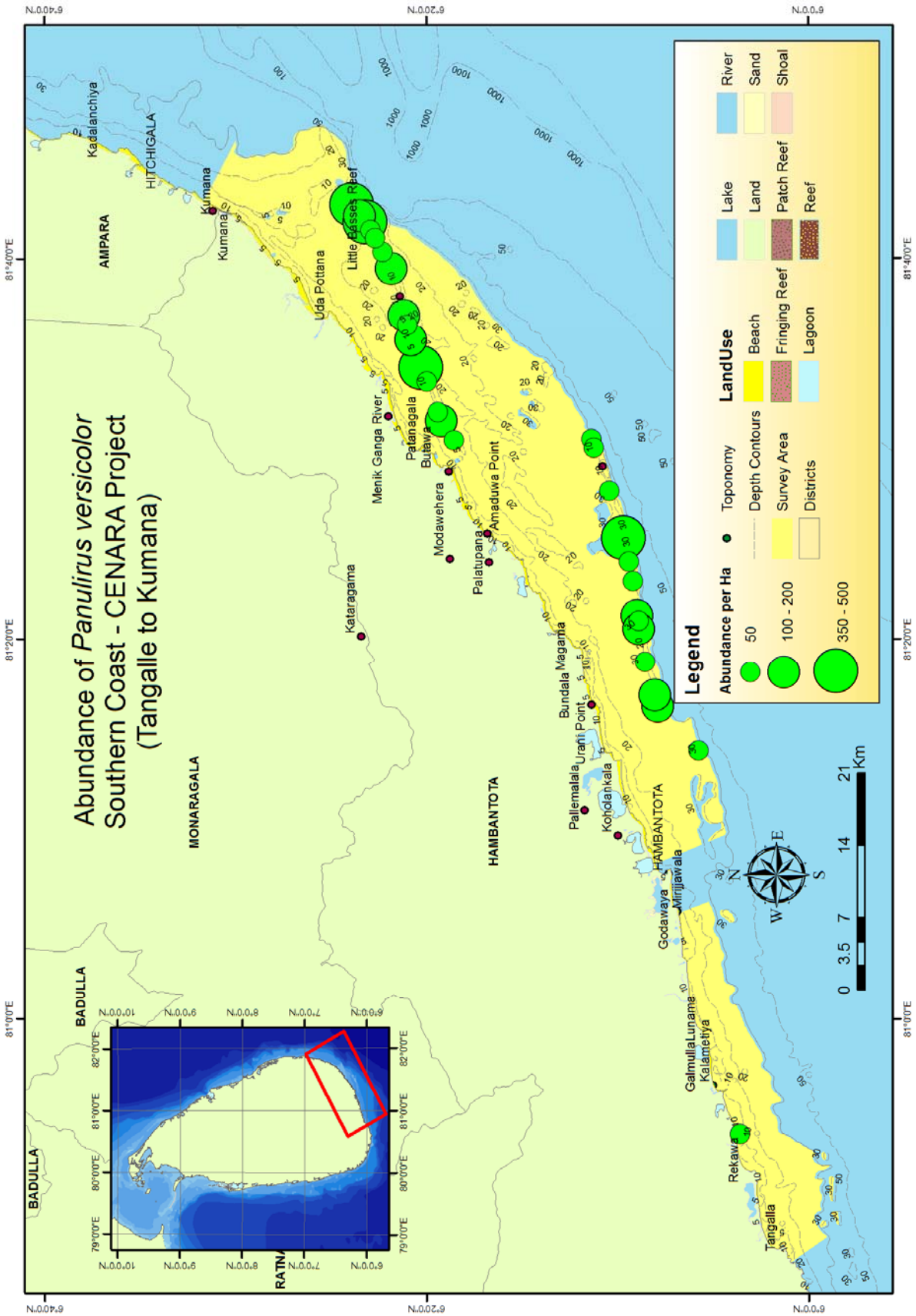

Figure 21 Distribution of the abundance of P.versicolor in the SCLFMA

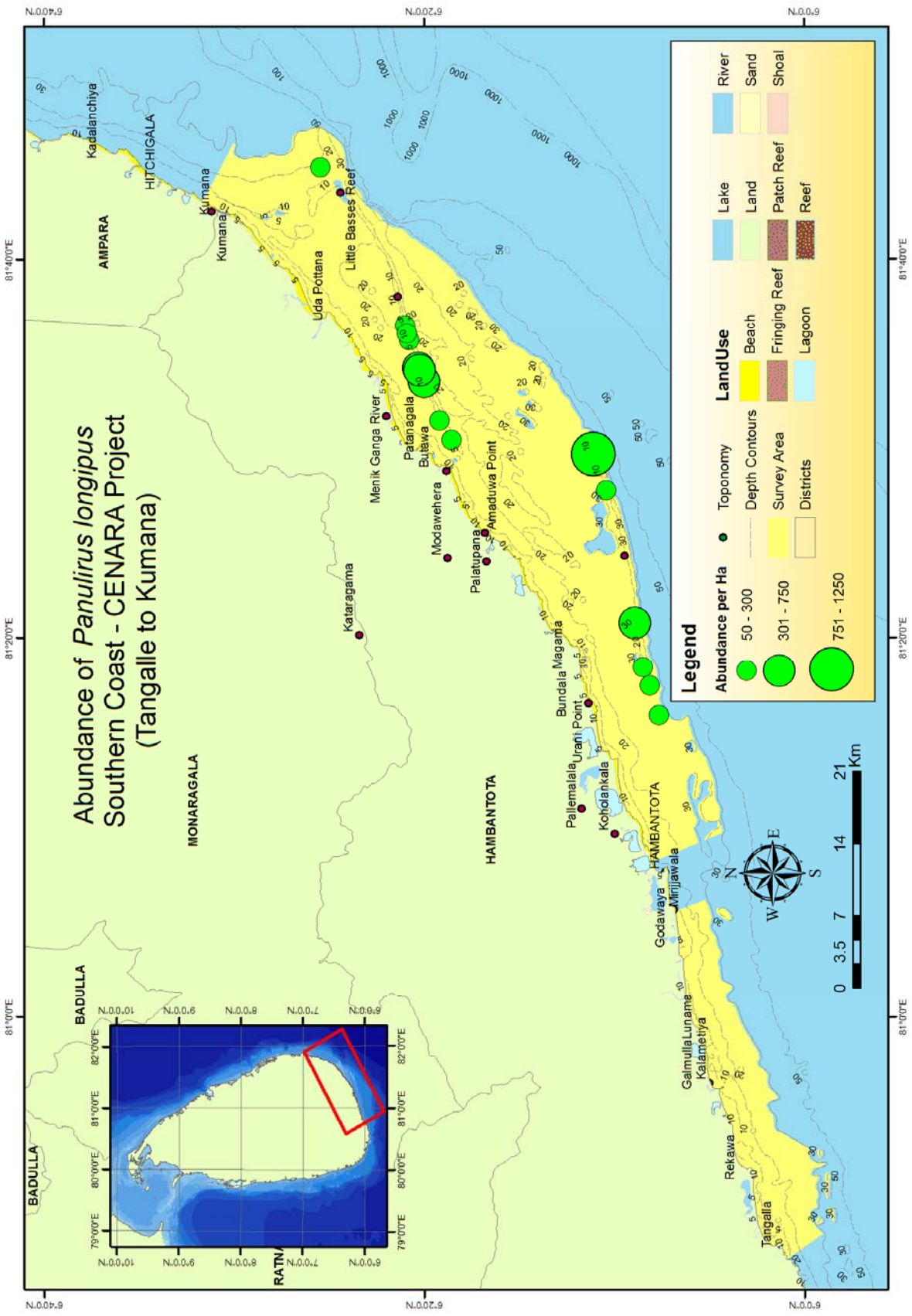

Figure 22 Distribution of the Abundance of P. longipes in the SCLFMA

Biomass

Table 11 Spiny lobster standing stock estimates. Biomass: MSY: TAC:

Species	Biomass (Kg)	*MSY*	TAC
Panulirus homarus	100360	10036	5018
Panulirus longipes	36945	3694	1847
Panulirus ornatus	-	-	-
Panulirus penicillatus	18681	1868	934
Panulirus polyphagus	0	0	0
Panulirus versicolor	78942	7894	3947
Total	234929	23492	11746

According to the table 11 the highest biomass volume was recorded by the Scalloped spiny lobster - *P. hamarus, its* standing stock as 100360 kg. The maximum sustainable yield and the total allowable catch of the species are 10036 kg and 5018 kg respectively. The second highest biomass volume can be seen in *Panulirus versicolor* as 78942 kg. Maximum Sustainable Yield and the Total Allowable Catch of the species are respectively 7894 kg and 3947 kg. The Biomass of the *P. longipes* takes third place among the all spiny lobster species as 36945 kg. Its MSY and TAC values are estimated as 3694 Kg and 1847 kg respectively. *Panulirus ornatus* and *P. Polyphagus* species were not recorded from the surveying area.

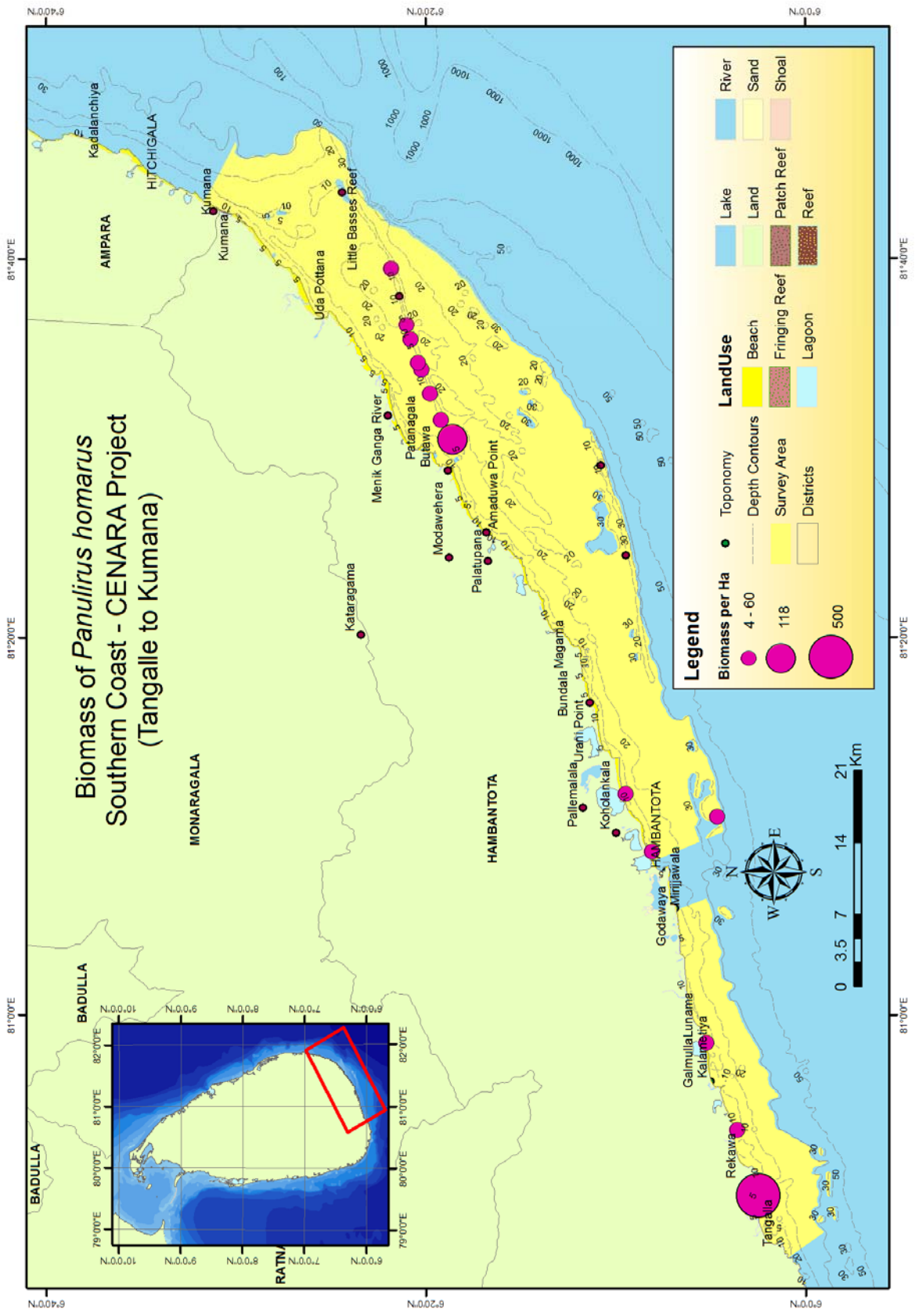

Figure 23 Distribution of the Biomass of *P.homarus* in the SCLFMA

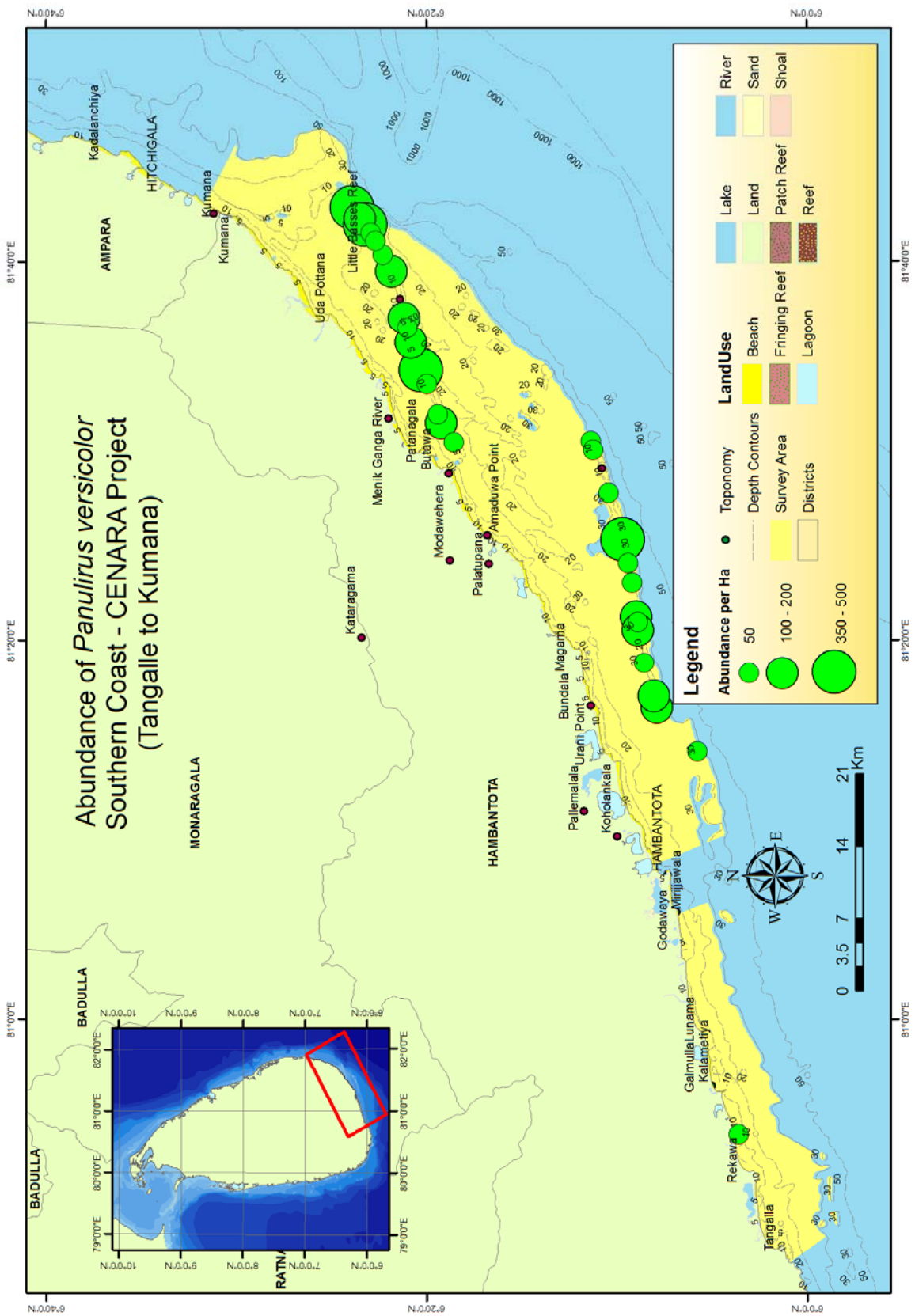

Figure 24. Distribution of the biomass of *P.versicolor* in the SCLFMA

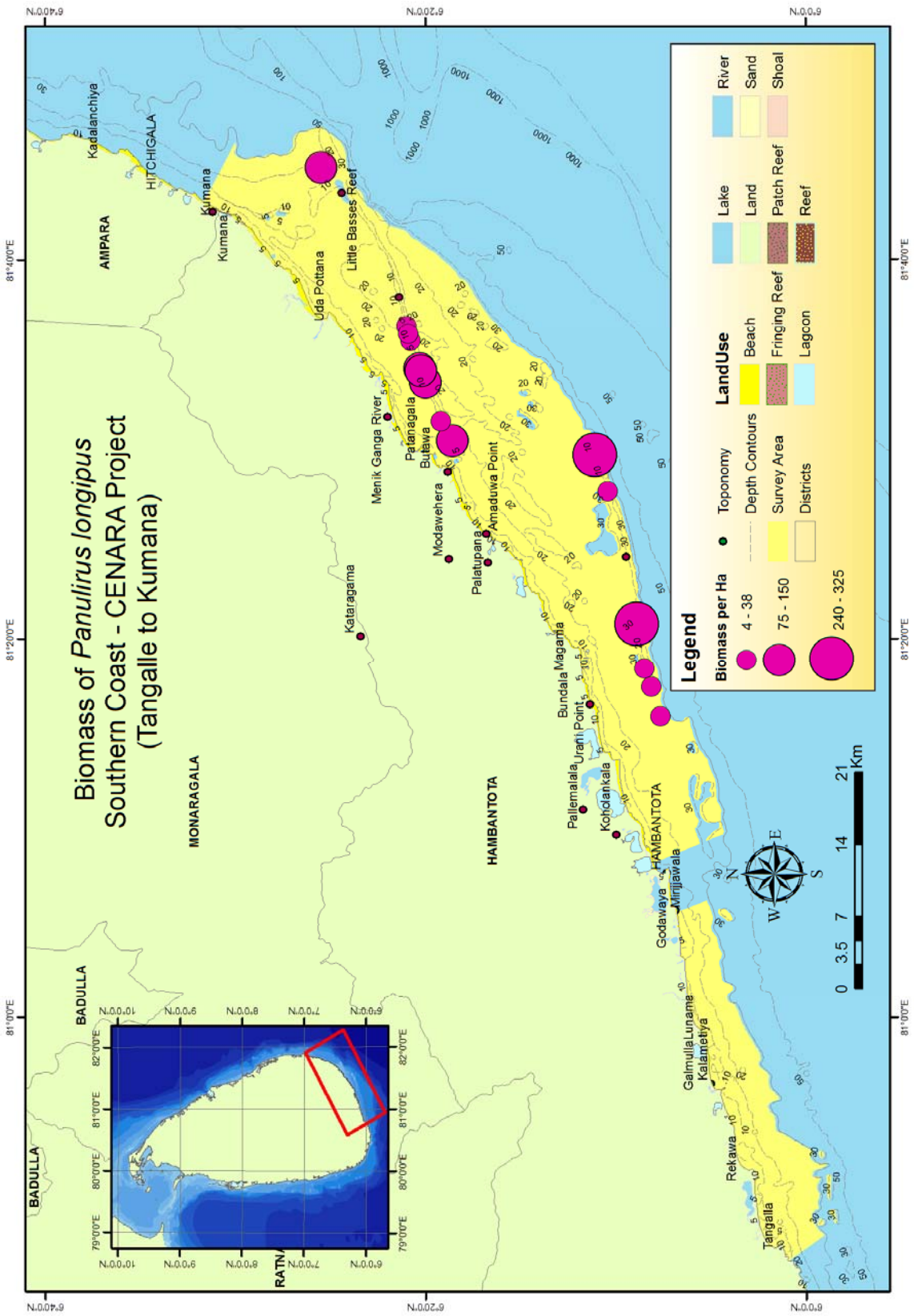

Figure 25 Distribution of the Abundance of *P. longipes* in the SCLFMA

Discussion

Lobsters are the most valuable crustacean species found in Sri Lanka coastal waters. High exploiting rate following the foreign demand, resulted depletion of the stocks. The depletion of the stocks are being reflected by the declining daily catch rates (Jayakody 1999 and Sanders 1996) and number of undersized lobsters in the catch and length frequencies. Several stock assessments works based on fisheries dependent data had being carried out during the past on *P. hamarus* the dominant species (Jayakody 1999, Jayawickrema 1990). It was assumed that the South coast lobster fishery was fully exploited resource since 1980,s (Jayakody 1999). According to the present fisheries independent assessment it is assumed that the total population of the *P. hamarus* in South Coast Lobster Fisheries Management Area (Tangalle to Kumana) are 349688. In 1991 Jayakody assumed that the total population of the *P.homarus* in the south coast (From Benthara river mouth to Kirindi Ganga Mouth) as 4047000 individuals and further he was suggested that the fishing effort should be reduced 20.5% to bring the stock to equilibrium point. Following the result of the past survey in year 1999, year 2000 the Hon. Minister of Fisheries brought an amendment to 1996 fisheries regulation, for management and conservation of the South coast lobster fishery. Result of the present study revealed that there was no any improvement of the stock size after introduction the new regulations and those regulations are violated by the fishermen due to various factors such as management, social and economical. The total biomass, Maximum Sustainable Yield and Total Allowable Catch of the study area is respectively 235 , 23 and 12 MT for the all lobster species other than the *P. ornatus*. During the year 2008 Sri Lanka had being exported 250 MT of the lobsters and from its over 60 % came from the south coast. Present lobster production (Based on 2008) of the South Coast Lobster Fisheries Management Unit is ten times higher than the calculated TAC. In year 1999 Jayakody estimated the MSY for the year 1996-97 of the south coast lobsters as 200 MT using the Scheafer and Fox models. In year 2007 Liyanage found that the large number of lobsters in the commercial catch represented the small length class groups. During the December 2007 fifty five percent of the catch consisted undersized lobster creating growth overfishing.

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Recommendations

- All the lobster stocks in the south coastal region are heavily exploited and at the same time majority of the lobster fishing population are not respected for the present lobster fisheries regulations. It is necessary to take an immediate action to conservation and management of the stocks and the ecosystem in collaboration with the resource users.

- Control the lobster fishing effort

  Special license should be introduced to the lobster fishermen to control the effort. Under present ground situation every craft owner who has the license for operate the gill nets can be fished lobsters. During the lobster fishing season too much fishermen are engage in the lobster fishery without respecting the rules and regulations. At the same time the outside divers came to the Kirinda area for the chank fishing collect big amount of lobsters while collect the chanks and sea cucumbers. Its create big problem on the net operators as well as on the resources. To control the fishing effort it is necessary to introduce a new license for the lobstermen. The new entry for the fishery must be controlled through the license system. At the same time the license should not issued for the outsiders of the district.

- Fishing quota system should be introduced based on the result of the present study and Long term monitoring is recommended for understanding the efficiency of the implementation. The recommended total allowable catch is 12 MT or 29630 individuals for all lobster species (Table 10 & 11).

- Establishment of the lobster sanctuary or Marine Protected Area (MPA)

  Some area should be declared as a lobster sanctuary with the support of the lobster fishes and parallel government institutions (Dept of Wild life). The berried lobsters entangle in the fishing nets must be release to the sanctuary paying little for them. The required funds could be collected through the imposing tax on the fisheries exports. The area close to the great basses reef (Fig 26) is most suitable for this purpose as it is about 16 km away from the land and less fishing pressure of the area.

- Introduction of new ecofriendly fishing gear.

  Priority must be given to the ecosystem conservation. Lobsters are inhibit in the rocky coralline areas. All the net operators (95%)who are used bottom set gill nets for lobster fishery, damaged the ecosystem. At the same time life time of their nets are very short due to the damages made by the rocks & corals. It is very urgent to introduction of new ecofriendly fishing gear to protect the ecosystem and reduced economic losses of the lobstermen.

  It is very important to introduction of new gear to minimize the amount of immature lobsters represent in the catch (Minimize the growth overfishing). Selecting factor of the net is invalid for the lobster fishery because of lobsters are entangled on the net.

- Indian lobster *P.polyphagus* is vanished from the southern coastal fishing grounds. This species should be name as protected species to stop the catch. Research should be directed to find the reasons for eradicate this species.

- Lobster breeding and releasing programmes should be started to reduce the fishing pressure on natural stock (Presently practiced in many countries).

- Present regulations imposed on the lobster fishery are completely based on the conservation & management of the stock and not considered about the fishes views and expectations. Lobster fishing rules and regulations should be update based on the fishes, fisheries scientist and fisheries managers opinions.

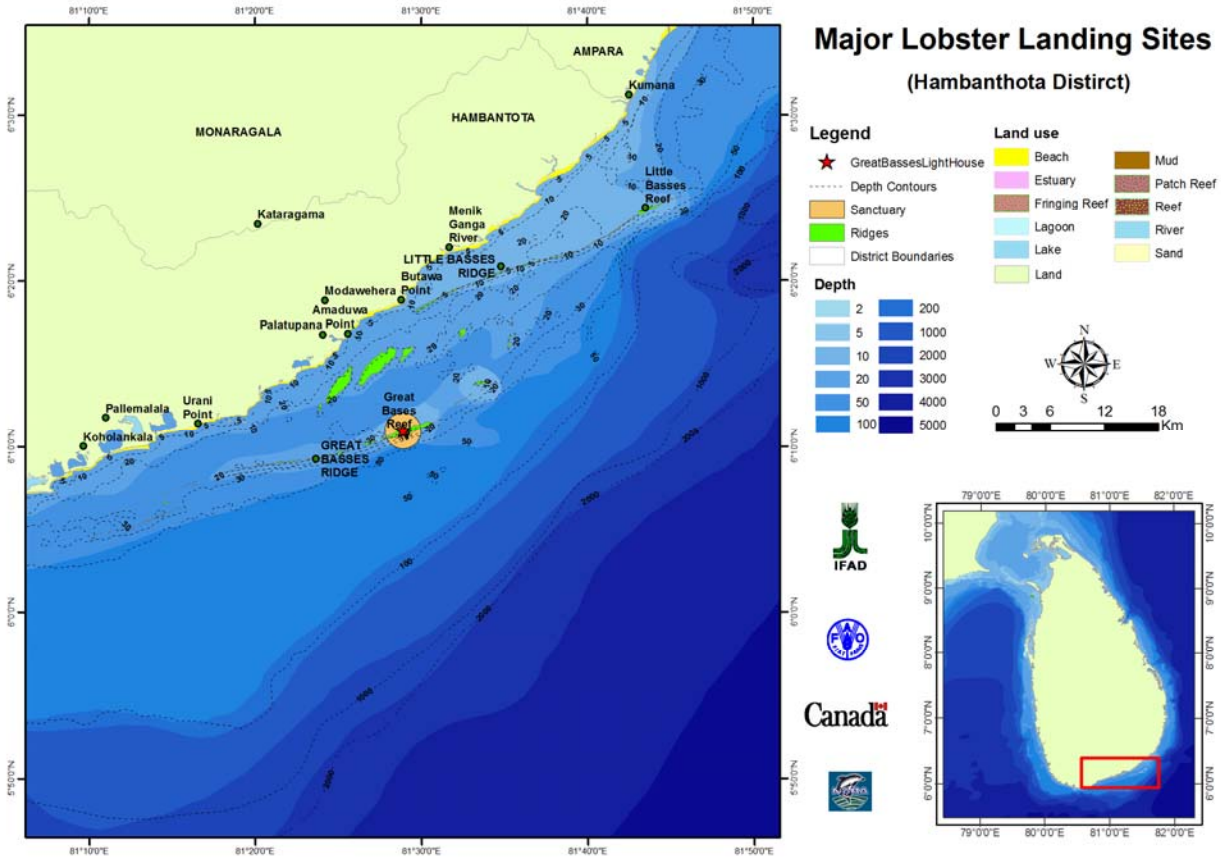

Figure 26. Proposed lobster sanctuary (MPA)

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Appendix 1 - Description of the Study Area

Climate

The climate of the area grades from Intermediate (rainfall 1250 mm) to arid (Rainfall below 1000 mm) from west to east. The coastal region of the Hambantota district is directly faced to the South West monsoon, but maximum rainfall receiving to the area during the Second Inter monsoonal period and the Maha season (From October to November & December to February). Severe droughts can be observed from June to August period. The mean annual temperature is 27 ^{0}C and it varies within 25 - 27.5 ^{0}C. The wind velocity range from 14 km/hr to 23 km/hr.

Administration

The District is administrated by the District Secretary of the Hambantota. The coastal region of the district is sub divided into four Administrative divisions Tangalle, Ambalantota, Hambantota and the Tissamaharamaya. Each division is administrated by the Divisional Secretary under the supervision of the District Secretary. Each Division again sub divided to the Grama Niladhari Divisions to facilitate the local administration system. The Assistant Director of Fisheries – Tangalle, is key person responsible for the marine fisheries management and welfare of the fishes in the district. The Coastal area of the district is divided into Fisheries Inspectors Divisions to facilitate the management and welfare.

The entire South Coast Lobster Fisheries Management Unit falls within the Hamanthota district.

Fisheries

Most of the people who are living in the coastal belt of the district directly or indirectly depended on the marine capture fisheries. Culture fishery and inland capture fishery are not commonly practiced fishing methods in the coastal region. With the recent fisheries development considerable amount of fishermen fishing in the offshore or international seas with the 10-15 m length multiday crafts equipped with GPS, Communication instruments and Ice storage facilities. These fishermen landed their catch at four commercial fisheries harbors Kudawella, Tangalle, Hambantota and Kirinda in the district. Several Ice factories and fuel sheds are located in harbors or their vicinity to facilitate the fishing operations. Number of craft operating in the near shore and offshore areas were bloomed to double after the Tsunami with the grants given by the fisheries ministry, various NGOs and INGOs. The fishermen who were fishing in the near shore areas always complaining that their catch rates are declining day by day due to the over exploitation of the stocks. These complains are most common for the highly valuable coastal living species such as spiny lobsters.

Two distinctive fishing seasons can be observed following the Southwest and Northeast monsoonal periods (Handawala 2000). The south monsoonal period start from May and it ends in August. Most of the small craft operated fishermen (FRP, NMTC, MTC) loss their jabs during the season due to rough sea which is accelerated by the South west monsoonal winds. During the calm season September to April most of the small scale fishermen are fishing in the near shore regions of the district.

Appendix 2 – Stratified Sampling

In stratified sampling the population of N units is divided into subpopulations of $N_1 \ldots N_L$ units respectively. If each stratum is homogenous in that the measurements vary little from one unit to another, precise estimates of any stratum mean can be obtained in that stratum. These estimates can then be combined to give a precise estimate for the whole population. The notation of terms used for stratified sampling follows below:

N	total number of possible sampling units in the study area;
N_h	total number of possible sampling units in stratum h;
n_h	actual number of samples taken in stratum h;
y_{hi}	value obtained from ith unit in stratum h;
$W_h = \frac{N_h}{N}$	stratum h weight;
$f_h = \frac{n_h}{N_h}$	sampling fraction in stratum h;
$\bar{y}_h = \frac{\sum_{i=1}^{n_h} y_{hi}}{n_h}$	stratum h mean;
$\bar{y}_{st} = \sum_{h=1}^{L} W_h \bar{y}_h$	stratified mean over all strata;
s_h^2	sample estimate of stratum h variance;
$v(\bar{y}_{st}) = \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{n_h} \sqrt{\sum_{h=1}^{L} \bullet \frac{W_h s_h^2}{N}} \times$	estimated strata variance.