CENARA Project

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Optimizing Trawl Length for Sampling Prawns at Kalpitiya

CENARA Project Reports on Trawling

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Executive Summary

A study was done to compare the capture efficiency of 1 km and 2 km trawls for carrying out fisheries independent surveys of prawns in the existing trawl fishery at Kalpitiya north western Sri Lanka; information that can be used for optimizing trawl length for future sampling programs. Fifty-nine trawls were done at 1 or 2 km. The analysis of capture efficiency compared pooled abundance of prawns. The results of the study indicated that:

- Optimal trawl distance for sampling prawns was 2 km;
- Less than half (6 out of 14 trawls) of the sites sampled in the proposed trawl grounds had prawns in the catch. These preliminary data are not an encouraging result for justifying an extension of prawn trawling grounds to the proposed trawl grounds. In contrast 41 of the 45 sites sampled in the existing trawl grounds had prawns in the catch. Fisheries managers will need to carefully weigh up the advantages and disadvantages of trawling in these unfished waters. It also highlights the importance of doing a survey of the proposed grounds;
- Areas predicted to have prawns based on clear spatial patterns in distributin and abundance of prawns in relation to habitat type should be factored into the survey design for sampling the proposed trawl grounds;
- An impracticably large (150) number of trawls are required to obtain reliable estimates of the mean (95% confidence intervals approximately 10% of the mean) and hence standing stock;
- Consequently the results of fisheries independent survey must be interpreted along with data on trawl catch landings when making fisheries management decisions;
- Estimates of static prawn standing stock (snapshot) in the existing trawl grounds obtained by a fisheries independent survey needs to be analyzed against landed catches to quantify the importance of the influx of prawns – if any - into the existing trawl grounds; and
- Fisheries managers must understand the implications of reliability in the estimates of standing stocks of prawns when setting Total Allowable Catches based on fisheries independent data.

Based on cost and time constraints we recommend that at least 80 trawls be sampled in the proposed trawl grounds north of the existing trawl grounds.

Introduction

The CENARA project aims to enhance the capacity of NARA to undertake fisheries independent surveys of selected marine resources in Sri Lanka. The prawn and by-catch fishery at Kalpitiya off the coast of northwestern Sri Lanka was selected because of its economic importance to the local community there.

With the recent cessation of hostilities between Sri Lanka and LTTE the local community has expressed a desire to expand the existing trawl grounds northwards to Puvarasu Odai.

The three overarching objectives of the trawl component of CENARA were to:

1. Undertake a fisheries independent survey of prawns and by-catch in the existing trawl grounds and relate these standing stock estimates with landed catches (fisheries dependent data);
2. Map seabed habitats of the area proposed for expansion of the fishery to determine suitability for trawling; and
3. Sample the proposed trawl grounds to obtain estimates of standing stock for prawns and by-catch.

However, before the survey proper of the proposed trawl grounds commenced it was necessary to do a study to establish the field sampling methods, trial the gear and determine the optimal trawl length for sampling prawns.

Prawns were selected as the target taxa because of their high economic value. Other taxa in the by-catch are commercially important and were also sampled but are not discussed in this report.

The purpose of this study was to compare the capture efficiencies of 1 km and 2 km trawls for sampling prawns in the study area and to estimate the number of trawls required for reliable estimates of prawn standing stock.

Material and Methods

Description of the Study Area

Existing and Proposed Trawl Grounds

The existing trawl grounds (26 km^2) are located off Kudremalai Point in north western Sri Lanka (Figure 1). The proposed trawl grounds (85 km^2) lies to the north and north-east of the existing trawl grounds and extends to Puvarasu Odai.

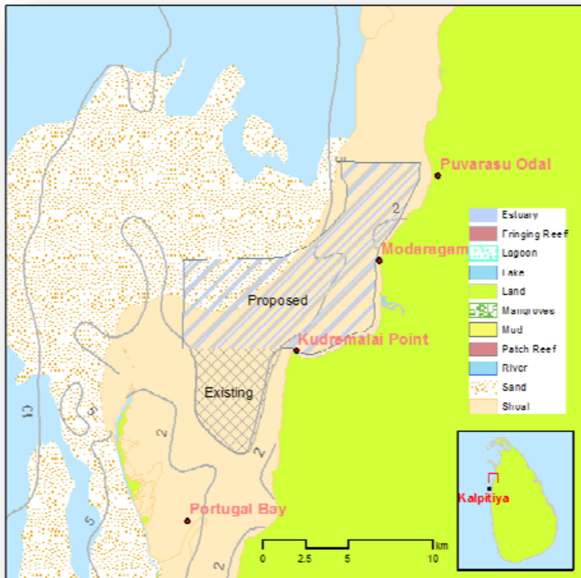


Figure 1. Location of the study area showing existing and proposed new trawl grounds.

Bathymetry and Seabed Habitats

The existing trawl grounds 26 km^2 is mostly shallow water with 52% (14 km^2) of the area < 5 m deep and the remaining area 5 – 10 m deep (Table 1).

The proposed trawl grounds 85 km^2 is three times larger than the existing trawl grounds (26 km^2). Half the area of the proposed trawl grounds (43 km^2) is < 5 m deep and the remaining 42 km^2 between 5 and 10 m deep.

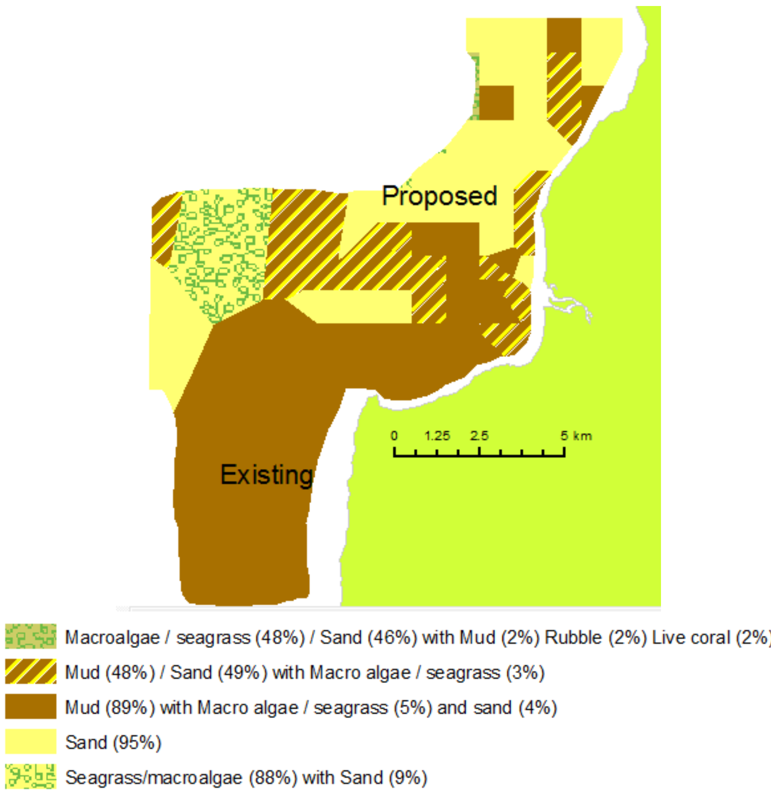
Table 1. Bathymetry: depth classes for existing and proposed trawl grounds.

Trawl Grounds	Area km^2	% Total
Existing	26	
0-5 m	14	52%
5-10 m	13	48%
Proposed	85	

0-5 m	43	50%
5-10 m	42	50%
Grand Total	111	

The seabed habitats classified using % cover of substratum types from 92 sampled by divers indicated that the existing trawl grounds were seabed habitat: Mud (89%) with Macro algae / seagrass (5%) and sand (4%)[1] (Figure 2; Table 2).

In contrast the proposed trawl grounds was a mixture of seabed habitats with a third of the area Sand (34.5%) and the remaining a variation of Mud, Macroalgae / Seagrass and Sand.



[1] For a full description of the seabed habitat mapping and bathymetry refer to Long et al. (2009)

Figure 2. Seabed habitats mapped in the existing ad proposed trawl grounds.

Table 2. Seabed habitats: existing and proposed trawl grounds.

Trawl Ground	Seabed Habitat	Area km^2	%Total
Existing	Mud (89%) with Macro algae / seagrass (5%) and sand (4%)	26.0	99.2%
	Sand (95%)	0.2	0.8%
Existing Total		26.2	100.0%
Proposed	Macroalgae / seagrass (48%) / Sand (46%) with Mud (2%) Rubble (2%) Live coral (2%)	0.4	0.3%
	Mud (48%) / Sand (49%) with Macro algae / seagrass (3%)	19.9	18.0%
	Mud (89%) with Macro algae / seagrass (5%) and sand (4%)	25.6	23.1%
	Sand (95%)	29.1	26.3%
	Seagrass/macroalgae (88%) with Sand (9%)	9.5	8.6%
Proposed Total		84.5	76.4%
Grand Total		110.7	100.0%

Survey design

The survey was designed with GIS. Fifteen sites were positioned in the proposed trawl and 49 in the existing trawl grounds (Figure 3). Sites were positioned randomly for 1 km trawls. The 2 km trawls used a systematic sampling design with trawls oriented north south.

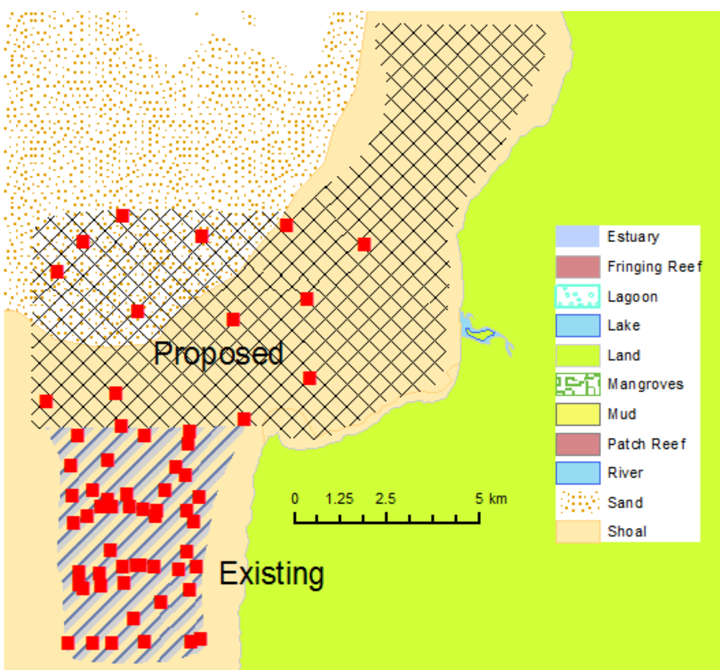


Figure 3. Sample design showing start positions of trawls in the existing and proposed trawl grounds.

A local trawl fisher was contracted to carry out sampling for the study. The trawler was a 11.6 m in length and with 65 hp motor (Figure 4). The net used had 2.5 to 4.00 cm mesh and cod end of 2.00 cm. The width of the trawl was 9.38 m with a 27.7 m head rope. Two periods were sampled: 21-October to 18-November 2008 (29 sites) and 8 to 19 January 2009 (30 sites). The net was lowered and raised by hand by three crewmen. Trawl catches were emptied onto the deck sorted into main taxa, labeled and stored on ice. Samples were further processed – measured and weighed - back at the NARA research station at Kalpitya.

A total of 59 sites were trawled: 24 x 1 km trawls and 35 x 2 km trawls.

Time to Trawl

Based on time to travel between sites and time to sample a site 6 x 1 km trawls could be completed in a day whereas 4 x 2 km trawls could be completed in that same time.

(a) (b)

Figure 4. (a) Trawler used for the study; (b) catch being raised by hand.

Data Analysis

The abundance of prawns per trawl was calculated as the product of the trawl width (9.38 m) and trawl distance for both cod end and net. Trawl distance was calculated using GPS coordinates recorded at the start and end of each trawl.

All abundances were converted to abundance per ha for the analyses.

ANOVA was used to test for significant differences in Log_e +1 transformed abundance of prawns between 1 and 2 km trawls. A log transformation was used to normalize the data (Sokal and Rohlf 1995).

The variance of prawn abundance per ha for 1 km and 2 km trawls was tested for significant difference in variance using the F-test.

The variance of trawl distance for trawls grouped into 1 km and 2 km categories was also tested for significant differences in variance using the F-test.

Results

Trawl distance

Although all efforts were made to trawl for 1 or 2 km deviations occurred because of a variety of factors attributed to weather, sea conditions and raising and lowering the net. A frequency histogram indicated that there was a highly significant difference ($p < 0.001$) between variances of trawl distances for 1 km and 2 km trawls (Figure 5).

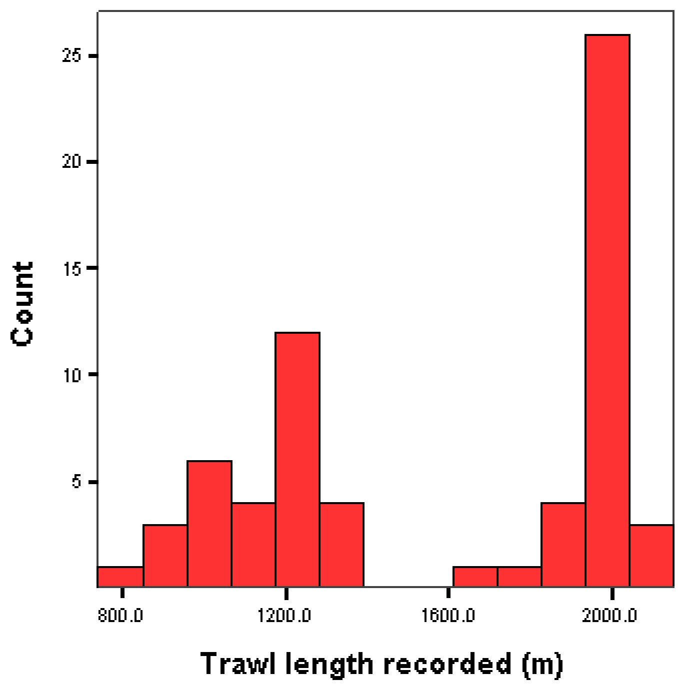


Figure 5. Frequency histogram of actual trawl distances recorded by GPS

Prawn Abundance

The average abundance for 1 km trawls was 34.72 individuals per ha and ranged from none to 201.2 ha^{-1}; the average abundance of prawns per ha in the 2 km trawl was 27.72 and ranged from none to 101.8 ha^{-1} (Table 3).

Table 3. Statistics for pooled prawn abundance for 1 and 2 km trawls. A: Abundance /ha; *N* = 24 for 1 km trawls; *N* = 35 for 2 km trawls.

Trawl Length	Maximum	Mean	Std. Error	Std. Deviation	Variance
1 km Trawl	201.2	34.72	10.15	49.74	2,474
2 km Trawl	101.8	27.72	4.27	25.24	637

Examination of a bubble plot of prawn abundance (ha^{-1}) indicated that highest abundances were in the existing trawl grounds (Figure 6). In contrast only half the sites sampled in the proposed trawl grounds had prawns in the catch.

The abundance of prawns was highly associated with seabed habitat. Of the 14 sites sampled in the proposed study area six of the seven sites with prawns were located in Mud habitat or Macroalgae / Seagrass habitat.

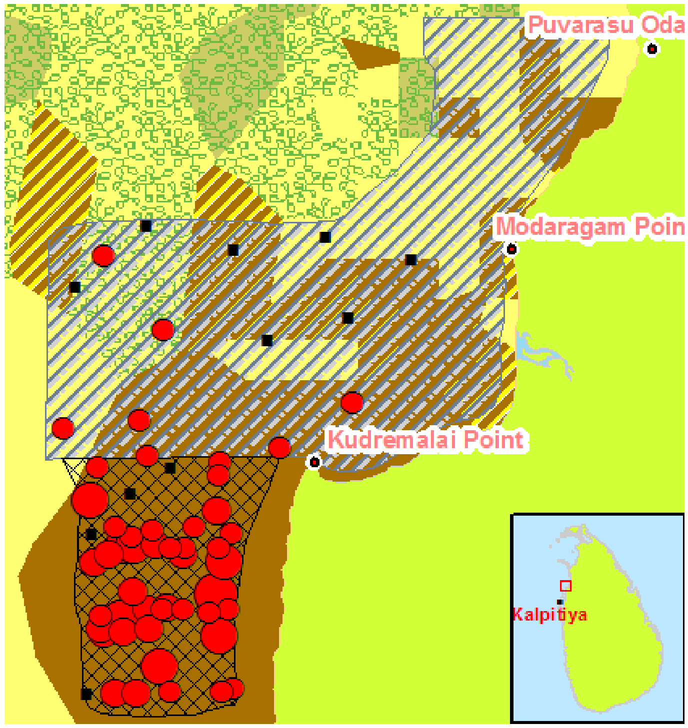


Figure 6. Bubble plot showing abundance of prawns /ha in the existing and proposed trawl grounds.

The variance of 1 km trawls (2,474) was significantly ($p < 0.001$) greater than 2 km trawls (637). $Log_e + 1$ transformed data was used for ANOVA testing differences in prawn abundance between 1 and 2 km trawls.

There was no significant difference in prawn abundance between 1 and 2 km trawls (Table 4; Figure 6).

Table 4. ANOVA comparing log_e +1 transformed abundance of prawns for 1 and 2 km trawls.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.40	1	5.4	2.25	0.14
Within Groups	136.74	57	2.4		
Total	142.14	58			

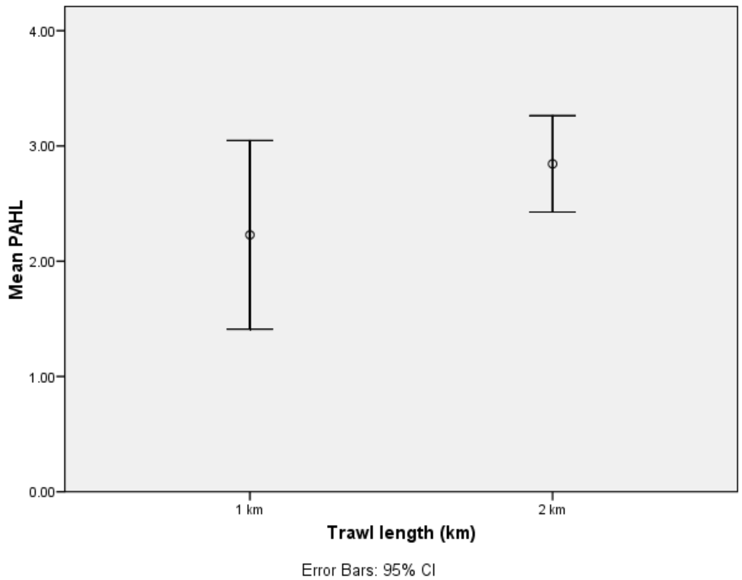


Figure 7. Plot of log_e +1 transformed prawn abundance against trawl length.

Standing stock Sample size

The variance of prawn abundance: 2,474 and mean 34.72 individuals per ha for 1 km trawls and variance of prawn abundance 637 and mean 27.72 for 2 km trawls was used to estimate the number of trawls required for Upper and Lower 95% Confidence Intervals (CI) estimates of standing stock (Table 5).

The results showed that for 2 km trawls at least 150 trawls were required to have 95% confidence intervals within 10% of the mean (Table 5). In contrast at least 450 trawls would be required for the same level of precision for 1 km trawls.

Table 5 Sample size, lower and upper 95% confidence intervals for 1 and 2 km trawls. %Mean 1 km trawls: (U95%CI [1 km trawls] – [Mean 1 km trawls])/Mean (1 km trawls).

N	StdErr [1 km trawls]	L95%CI [1km trawl]	Mean [1 km trawl]	U95%CI [1 km trawls]	% Mean [1 km trawls]	StdErr [2 km trawls]	L95%CI [1 km trawls]	Mean [2 km trawl]	U95%CI [1 km trawls]	% Mean [2 km trawls]
50	49.5	1.1	34.7	68.3	49%	12.74	19.06	27.7	36.38	31%
100	24.7	18.0	34.7	51.5	33%	6.37	23.41	27.7	32.03	16%
150	16.5	23.6	34.7	45.9	24%	4.25	24.85	27.7	30.59	10%
200	12.4	26.4	34.7	43.1	19%	3.19	25.57	27.7	29.87	8%
250	9.9	28.0	34.7	41.4	16%	2.55	26.00	27.7	29.44	6%
300	8.2	29.2	34.7	40.3	14%	2.12	26.29	27.7	29.15	5%
350	7.1	29.9	34.7	39.5	12%	1.82	26.49	27.7	28.95	4%
400	6.2	30.5	34.7	38.9	11%	1.59	26.64	27.7	28.80	4%
450	5.5	31.0	34.7	38.4	10%	1.42	26.76	27.7	28.68	3%

Discussion

The abundance of prawns was significantly more variable for the 1 than 2 km trawls. This was also shown by the high signal to noise ratio (standard deviation/mean) 1.6 for the 1 km trawls which was almost double the 2 km trawl (0.9). The higher variability may be caused by sampling artifacts associated with (1) more variable trawl distance; (2) raising and lowering the nets accompanied by bottom disturbance; patchy distribution of prawns; and possibly (3) sea and (4) weather conditions. Differences in sampling periods (Nov/Dec 2008) and Jan 2009 may have also contributed to this variability.

There was no significant difference in abundance of prawns for 2 km than 1 km trawls. There are a number of reasons that might explain this:

- Spatial and temporal patchiness in the distribution and abundance of prawns;
- Prawns escaping from the net – either actively or being forced through the net because of a build-up of by-catch - at a greater rate for 2 than 1 km trawls;
- A higher degree of clogging of the net for 2 than 1 km trawls creating a pressure wave at the mouth which is sensed by prawns who take avoidance action; and
- Chance.

These factors are not independent and may interact in subtle ways. It was not possible in this study to determine any causal factors that could explain the non significant differences in prawn abundance between 1 than 2 km trawls and further research is required.

The optimal trawl length was 2 km using pooled prawn abundance and variance as criteria. The much higher variability for the 1 m trawl would negate any advantages gained sampling more 1 km trawls per day i.e. 6 x 1 km trawls per day versus 4 x 2 km trawls.

Consequently a trawl of 2 km is recommended in future surveys.

The number of samples required for reliable estimates of standing stocks of prawns (e.g. 10% of the mean with 90% Confidence Interval) is impractically large (150+). Based on resources available – time and money – we recommend that the survey of proposed trawl grounds utilizes a samples size of at least 80 trawls. This should result in 95% Confidence Intervals that are approximately a fifth of the mean.

Fisheries managers must take into account the reliability of standing stock estimates when making decisions setting Total Allowable Catch (TAC).

The estimates of prawn abundance in the fisheries independent survey multiplied by area are a “snapshot” of the standing stock at the time of the survey. Although not part of this study it is vital to compare the “snapshot” with landed catches to evaluate the importance of influx of prawns – if any – into the trawl grounds. This topic is covered in the next CENARA Report on Trawling.

The high association between habitat and prawn abundance allows prediction of prawns in the proposed study area (Figure 8).

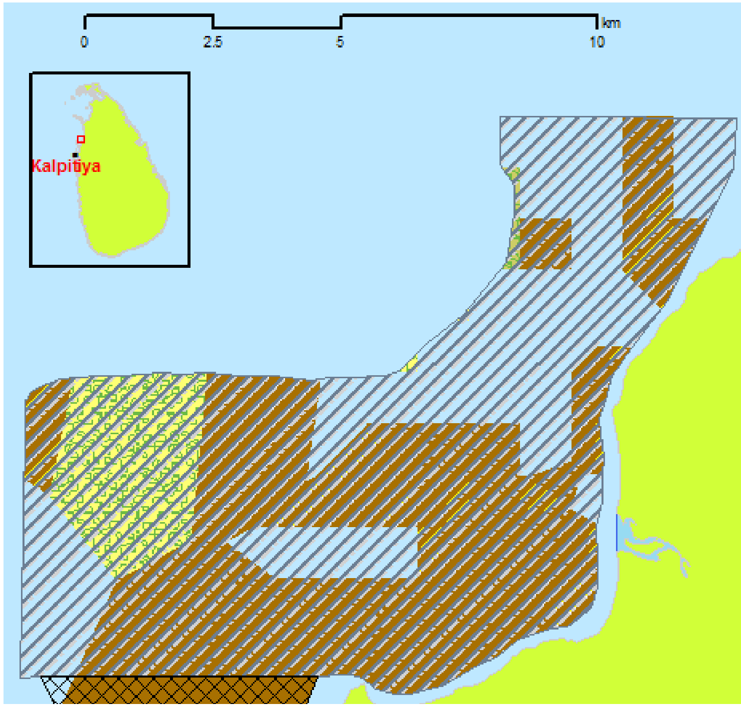


Figure 8. Areas predicted to have prawns in the proposed study area.

The survey design for sampling the proposed trawl grounds should be designed around the strata show in the Figure above.

Acknowledgements

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