Report of LB-SPR analysis

Areas: Surat Thani and Nakhon Si Thammarat provinces
Data Collection: BSC length data were collected between January and December 2023: Samples were collected from the fields every two months)

Background: The length-based spawning potential ratio (LB-SPR, Hordyk et al. 2016) has been conducted to assess the stock status of the blue swimming crab (BSC) in Surat Thani and Nakhon Si Thammarat fishing ground.

Sources of data: The BSC samples were collected from the fisherman landing sites in Surat Thani and Nakhon Si Thammarat provinces and conducted between January and December 2023. The details of BSC samples were showed in Table 1 (Surat Thani province) and Table 2 (Nakhon Si Thammarat province).

Table 1 Updated numbers and size of BSC samples collected from Surat Thani province

Gender	Number (individuals)	Min-length (cm.)	Max-length (cm.)	Average (cm.)
Male	1,264	6	15.5	10.78
Female	968	6.2	15.5	10.67
Total	2,232	6	15.5	10.73

Table 2 Updated numbers and size of BSC samples collected from Nakhon Si Thammarat province

Gender	Number (individuals)	Min-length (cm.)	Max-length (cm.)	Average (cm.)
Male	1,416	6.9	16.2	11.59
Female	1,232	6.6	16.0	11.51
Total	2,648	6.6	16.2	11.55

Data analyses: The asymptotic length was estimated by 0.95($Lmax$) and the curvature parameters was adjusted by using growth performance index (ϕ', Munro and Paly, 1983). The total, Z, mortality coefficient was estimated by the length converted catch curve (Pauly, 1984). Meanwhile, the natural, M, mortality coefficient was estimated by Rikhter and Efanov's Formula (Rikhter and Efanov, 1976) using size at 50% maturity from last year as input parameter as we strongly believed that there is no significantly change of biological parameter during a year. The fishing, F, mortality coefficient was estimated as Z-M. Size at selectivity was estimated through probability of capture curve (Pauly, 1984). The mentioned input parameters were estimated by using the FiSAT II package (FAO-ICLARM Stock Assessment Tool, Gayanilo et al., 2005). Meanwhile, the LB-SPR was estimated by using Package "LBSPR" for Program R (Hordyk, 2019).

The variation and error of samplings were minimized by collecting the BSC sample from the same fishermen and same landing sizes. The sample were collected based on covering all size class, smallest to biggest, to make sure we prepared high quality of LFD set for assessing biological and fishery parameters.

Results:

The maximum- and asymptotic- OCW of the samples collected from Surat Thani and Nakhon Si Thammarat were 15.5, 16.32 cm and 16.2, 17.05 respectively (Table 3). The curvature parameter (K) was 1.6 $year^{-1}$ (Fig. 1). The Z- and M- mortality coefficients for Surat Thani fisheries were estimated at 6.28 and 2.93 $year^{-1}$, respectively. While Z and M for Nakhon Si Thammarat were estimated at 5.30 and 2.89 $year^{-1}$ and then F-mortality coefficients for Surat Thani and Nakhon Si Thammarat were 3.35 and 2.41 $year^{-1}$ respectively (Fig2). The probability of capture curve (Fig. 3) revealed that size at 50% and 75% selectivity for Surat Thani and Nakhon Si Thammarat were 9.86, 10.45 cm and 10.59, 11.33 cm respectively. Length at 50% maturity ar was 9.96 cm (OCW) (Fig 3), which took about 0.5 year to reach this size. From these obtained parameters, the estimated spawning potential ratio (SPR) of the BSC stock

in Surat Thani and Nakhon Si Thammarat were at 0.47 and 0.57, respectively (Fig. 5 and 6).

Table 3 Input parameters and LBSPR results separately in each area.

Areas	Max-length (cm.)	Asymptotic length (cm.)	K	Z	M	F	Lc 50	Lc 75	Lm	SPR
Surat Thani	15.5	16.32	1.60*	6.28	2.93	3.35	9.86	10.45	9.96*	0.47
Nakhon Si Thammarat	16.2	17.05	1.60*	5.30	2.89	2.41	10.59	11.33	9.96*	0.57

Remarks* Assumed these parameters are no significant different in 2 years of study time

References

Gayanilo, F.C.Jr., Sparre, P., Pauly, D. 2005. FAO-ICLARM Stock Assessment Tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8, Revised version. Rome, FAO. 168 p.

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Hordyk A.R. 2019. LBSPR: Length-Based Spawning Potential Ratio. R package version 0.1.4. https://CRAN.R-project.org/package=LBSPR

Hordyk A.R., Ono K., Prince J.D. and Walter C.J. 2016. A simple length-structured model based on life history ratios and incorporating size-dependent selectivity: application to spawning potential ratios for data-poor stocks. Can. J. Fish. Aquat. Sci. 73: 1787–1799 (2016) dx.doi.org/10.1139/cjfas-2015-0422

Munro, J. L. and D. Pauly. 1983. A simple method for comparing the growth of fishes and invertebrates. Fishbyte 1 (1): 5-6

Pauly, D. 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Stud.Rev. (8):325p

Rikhter, V. A., and V. N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc., 76/VI/8: 12 p.

Appendix

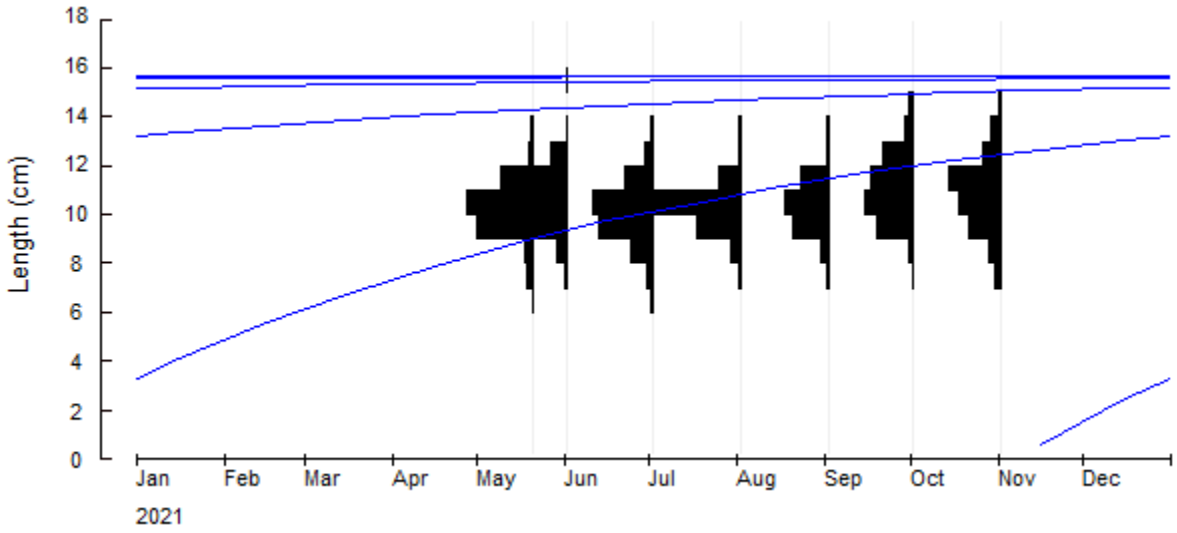
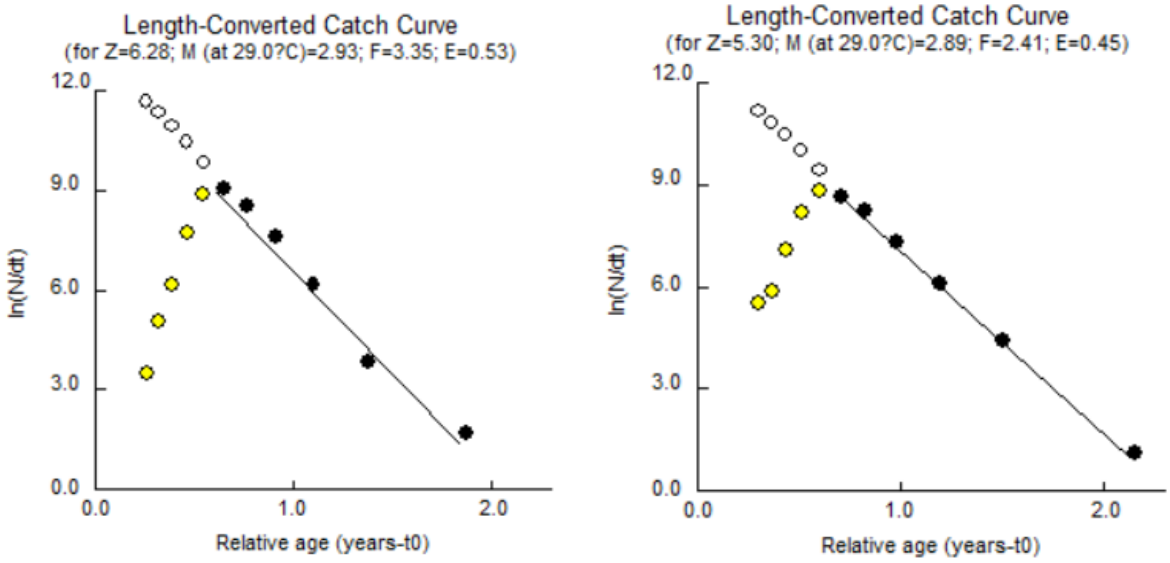


Fig. 1 Size distribution and growth curves of blue swimming crab, incorporated with the von Bertalanffy's growth curve.



(A) (B)

Fig. 2 Total mortality estimation from length converted catch curve in FiSAT from 12 months length frequency data used in this study (A) Surat Thani province (B) Nakhon Si Thammarat province

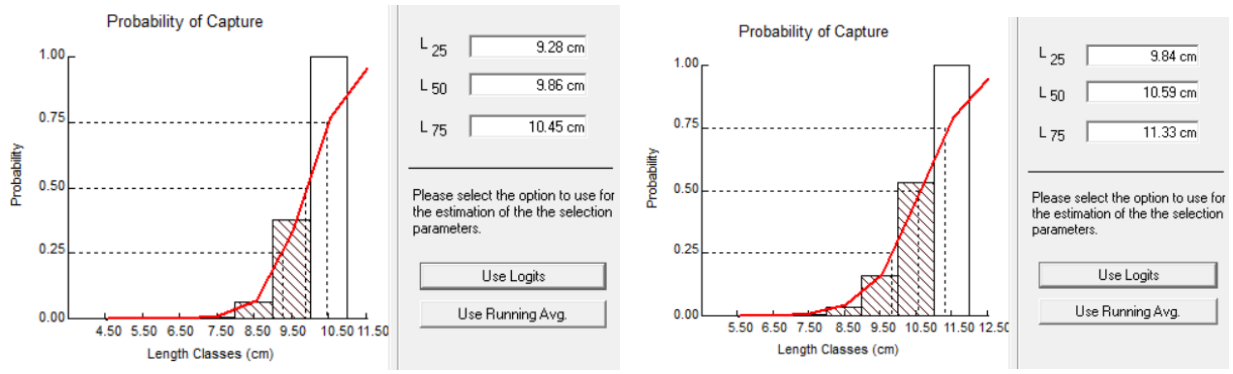


Fig. 3 Probability of capture of blue swimming crab calculated from 12 months length frequency data (A) Surat Thani province (B) Nakhon Si Thammarat province

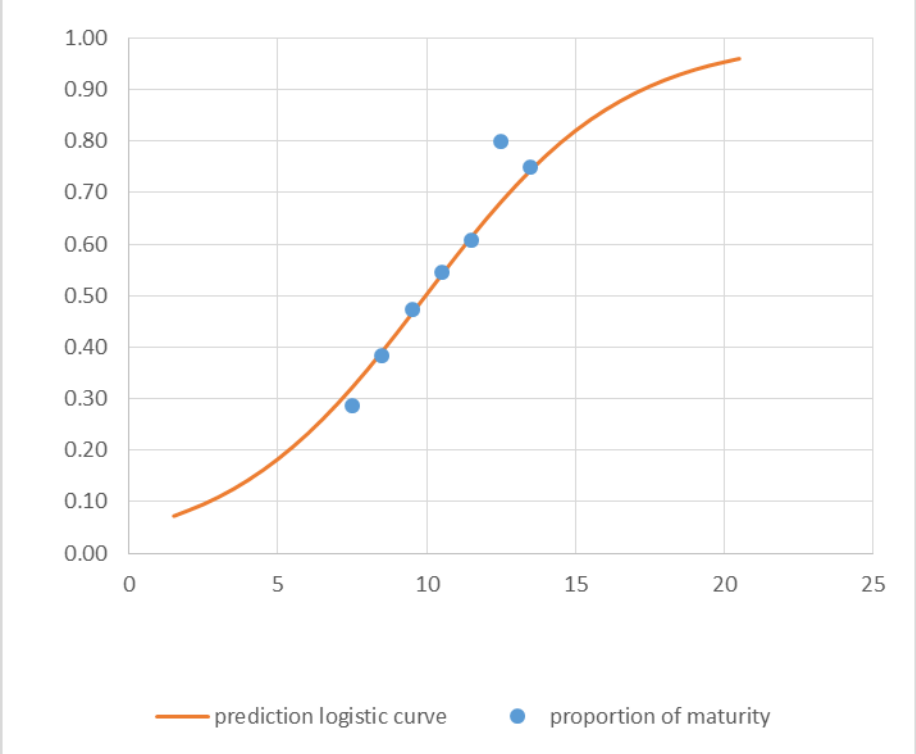


Fig. 4 Proportion of maturity of blue swimming crab calculated by logistic equation

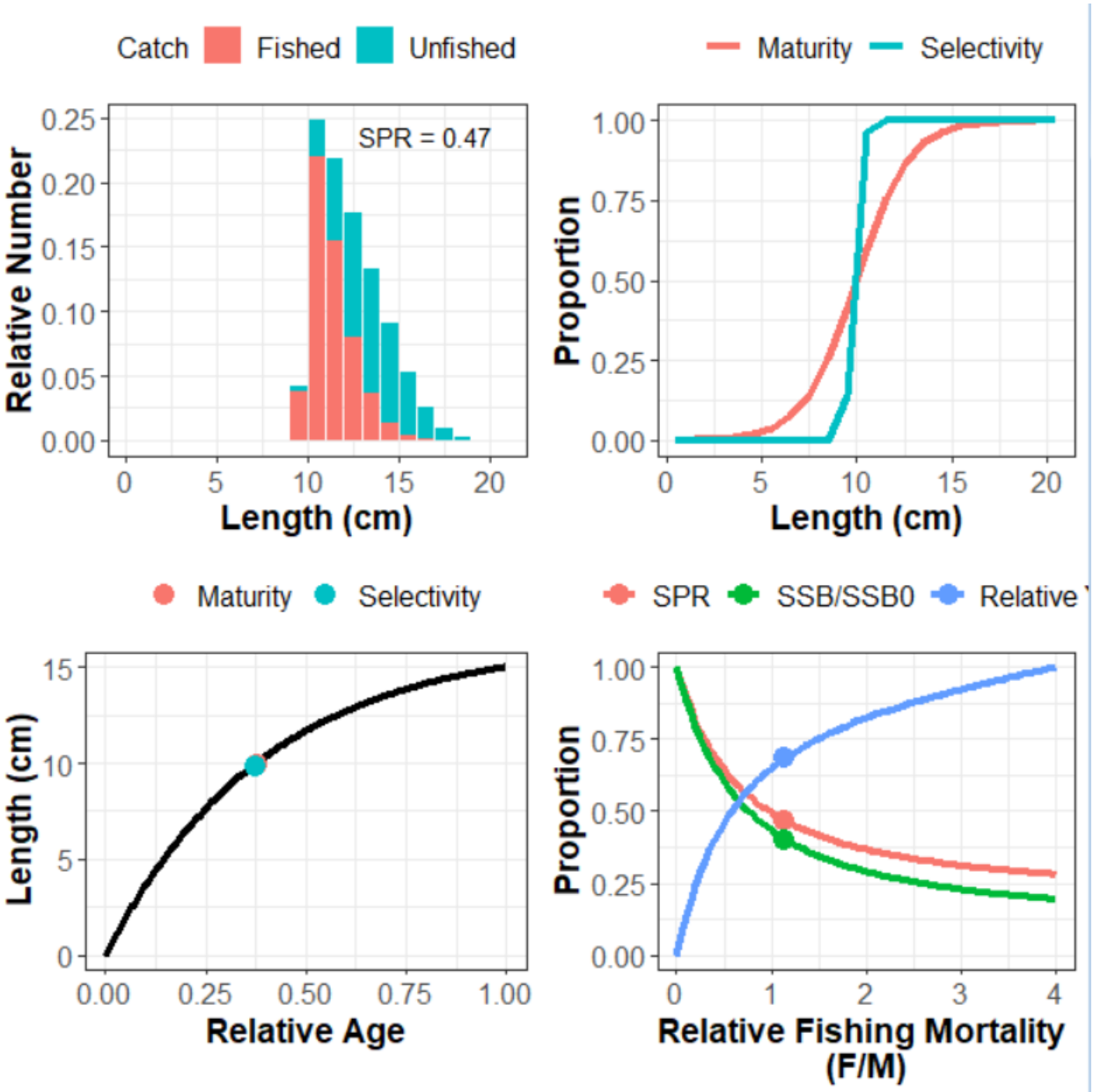


Fig. 5 Output from the LB-SPR analysis of blue swimming crab in Surat Thani.

(a) the expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population, (b) the maturity and selectivity-at-length curves, (c) the growth curve with relative age, and (d) the SPR and relative yield curves as a function of relative fishing mortality.

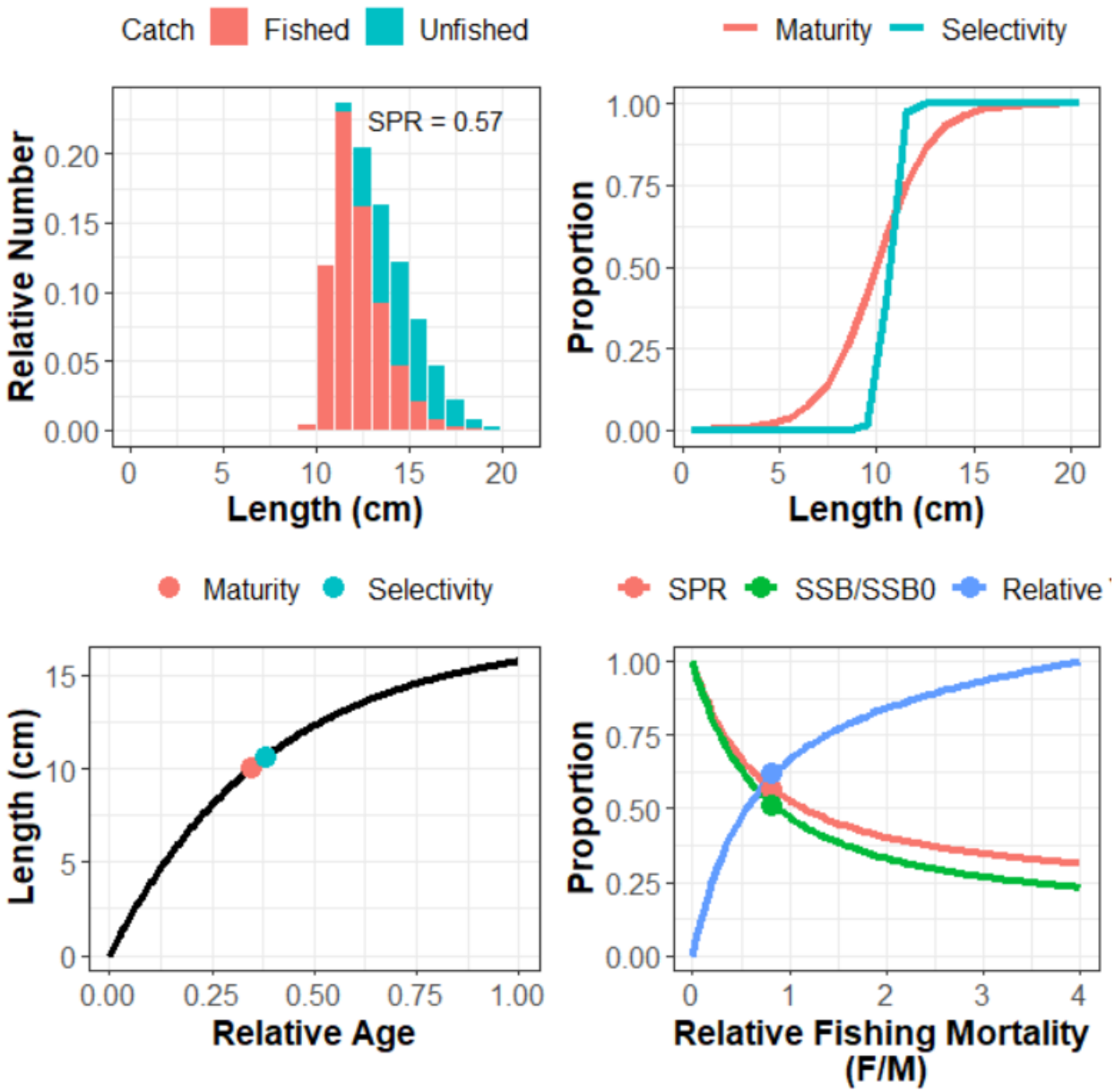


Fig. 6 Output from the LB-SPR analysis of blue swimming crab in Nakhon Si Thammarat.

(a) the expected (equilibrium) size structure of the catch and the expected unfished size structure of the vulnerable population, (b) the maturity and selectivity-at-length curves, (c) the growth curve with relative age, and (d) the SPR and relative yield curves as a function of relative fishing mortality.

Supplement Table 1 Length frequency data collected from Surat Thani province during January to November 2023

OCW mid-length	Month						
ML	January	Mar	May	July	Sept	Nov	Grand Total
5.5	1						1
6.5	1	4					5
7.5	3	4	18	3	1	10	39
8.5	17	25	51	27	7	36	163
9.5	50	89	128	104	58	71	500
10.5	60	96	134	210	116	86	702
11.5	51	60	57	110	156	58	492
12.5	39	30	30	15	100	21	235
13.5	7	7	14	7	30	13	78
14.5	1	2	1	3	1	5	13
15.5			1	1	2		4
Grand Total	230	317	434	480	471	300	2,232

Supplement Table 2 Length frequency data collected from Nakhon Si Thammarat province during January to November 2023

Count of L(cm)	Month						
ML	January	Mar	May	July	Sept	Nov	Grand Total
6.5	1	4	3	2	2	3	15
7.5	4	2	4	3	7	4	24
8.5	12	9	12	14	22	21	90
9.5	31	24	19	54	78	86	292
10.5	91	96	109	108	124	108	636
11.5	105	71	112	125	132	111	656
12.5	92	74	108	54	95	93	516
13.5	65	36	36	32	42	55	266
14.5	12	21	21	14	23	21	112
15.5	5	8	9	1	7	5	35
16.5	1	2	2		1		6
Grand Total	419	347	435	407	553	507	2,648

Supplement 3 Script for LBSPR analysis for Surat Thani province

```
library(LBSPR)
### Make scenrio ###
MyBSC <- new("LB_pars")
MyBSC@L_units <- "cm"
MyBSC@BinWidth <- 1
MyBSC@BinMax <- 21
MyBSC@BinMin <- 0
### Biology parameters
MyBSC@Linf <- 16.32
MyBSC@L50 <- 9.96 ##Length at 50% maturity
MyBSC@L95 <- 14 ##Length at 95% maturity
MyBSC@MK <- 1.83 ##M/K ratio M=2.93, K = 1.6
### Exploitation
MyBSC@SL50 <- 9.86 # Probability of capture
MyBSC@SL95 <- 10.45 # Probability of capture
MyBSC@FM <- 1.14
### Run the LBSPR simulation model.
BSCSim <- LBSPRsim(MyBSC)
BSCSim@FM
plotSim(BSCSim)
```

Supplement 4 Script for LBSPR analysis for Nakhon Si Thammarat province

```
library(LBSPR)
### Make scenrio ###
MyBSC <- new("LB_pars")
MyBSC@L_units <- "cm"
MyBSC@BinWidth <- 1
MyBSC@BinMax <- 21
MyBSC@BinMin <- 0
### Biology parameters
MyBSC@Linf <- 17.05
MyBSC@L50 <- 9.96 ##Length at 50% maturity
MyBSC@L95 <- 14 ##Length at 95% maturity
MyBSC@MK <- 1.806 ##M/K ratio M=2.89, K = 1.6
### Exploitation
MyBSC@SL50 <- 10.59 # Probability of capture
MyBSC@SL95 <- 11.33 # Probability of capture
MyBSC@FM <- 0.83
### Run the LBSPR simulation model.
BSCSim <- LBSPRsim(MyBSC)
BSCSim@FM
plotSim(BSCSim)
```

Sampling Locations

(A) Map showing blue swimming crab sampling point in Surat Thani province

(A) Map showing blue swimming crab sampling point in Nakhon Si Thammarat province